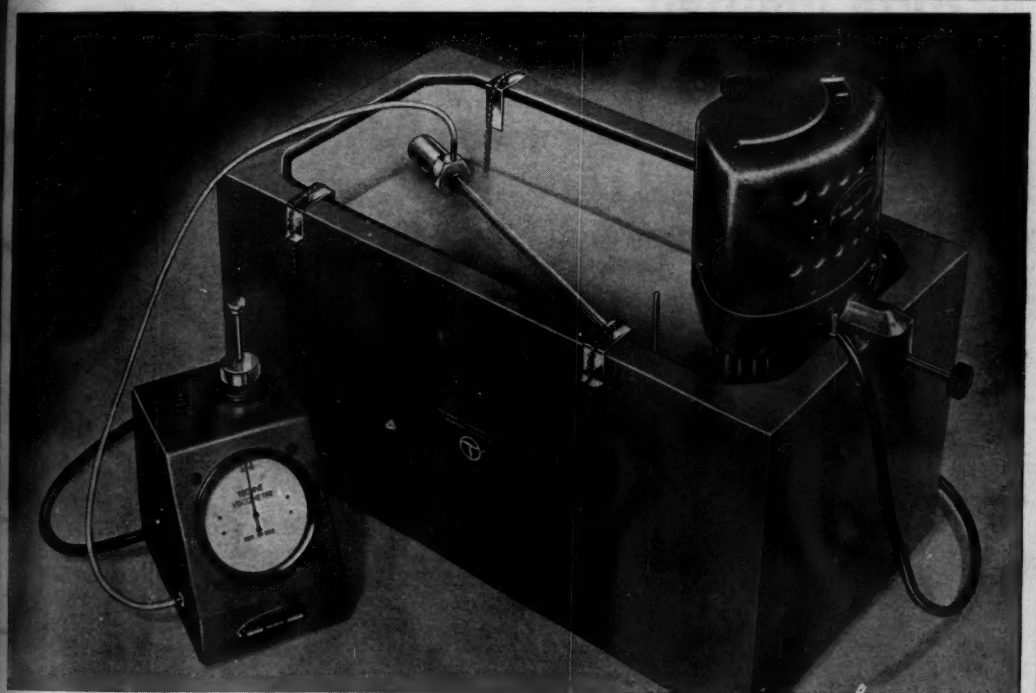
NATURE

A Weekly Journal of Science

UNIVERSITY OF MICHIGAN
APR 2 1959
PERIODICAL READING ROOM

Vol. 183, No. 4665 SATURDAY, MARCH 28, 1959 2s. 6d.



TECHNE

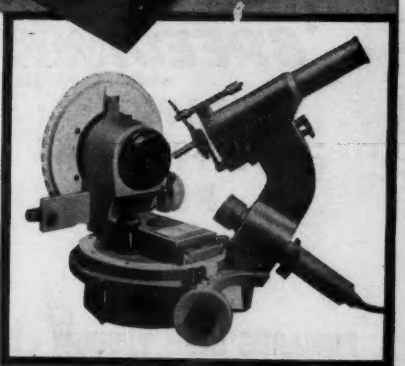
Thousands of our little temperature controllers (called Tempunits) daily give proof on both sides of the Atlantic of their accuracy and reliability. Above, a Tempunit is shown clamped to a water bath arranged for a viscosity determination with the Techne Absolute Viscometer.

The CM 2-Circle Optical Goniometer is designed specifically for users of the Barker Index, but well liked by crystallographers generally for its convenience and low cost. We shall be happy to tell you how these instruments work, what they cost, and why our customers have such confidence in them.

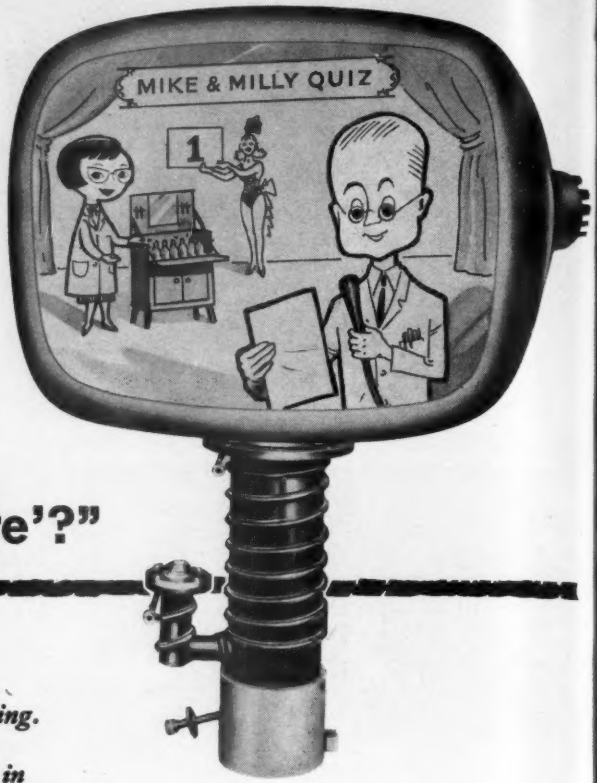
Write or telephone to:

TECAM

TECHNE (CAMBRIDGE) LIMITED
DUXFORD CAMBRIDGE ENGLAND Tel: Sawston 2246



An advertisement in the Edwards "Mike Ron" and "Milly Torr" series.



"What is 'High limiting backing pressure'?"

(A) *A system for controlling the odds on horse racing.*

(B) *A desirable characteristic in a vapour diffusion pump.*

(C) *The effect of reversing a car with the hand-brake on.*

"Milly Torr, give the gentleman who said (B) a prize. Give him this magnificent cocktail cabinet plus the Isle of Arran. A 'High limiting backing pressure' is a highly prized feature of 'Speedivac' high vacuum systems that utilise a 'Speedivac' vapour pump, leading to important economies—particularly with regard to the type of rotary pump necessary. How have Edwards achieved this? By the incorporation of an ejector or booster stage.

"Now molecules may not be able to think, but they can concentrate with a little persuasion, and that is just what this booster stage makes them do; they concentrate at the 'backing' port. This means that a single stage rotary pump can usually be used instead of a more expensive two-stage one."

"SPEEDIVAC" (Regd.)
VAPOUR DIFFUSION PUMPS

EDWARDS HIGH VACUUM LTD., MANOR ROYAL, CRAWLEY, SUSSEX, ENGLAND. *Crawley 1500*
MR.7

NATURE

No. 4665 SATURDAY, MARCH 28, 1959 Vol. 183

CONTENTS

	Page
Scientific and Technological Research in Britain	847
The Father of Chemistry. By Dr. R. E. W. Maddison	850
Plastics for the Practical Man. By Dr. S. H. Pinner	851
Mammalian Hair. By Dr. F. W. Dry	851
Theoretical Principles of Organic Chemistry. By Dr. P. B. D. de la Mare	852
American Marine Life. By Dr. D. P. Wilson	852
The South African Council for Scientific and Industrial Research. By Dr. S. M. Naudé	853
The Nuclear Research Centre, Grenoble	858
Obituaries:	
Prof. A. H. Gibson. By Prof. Jack Allen	859
Prof. G. V. Douglas. By Prof. G. C. Milligan	860
New Fellows of the Royal Society	860
News and Views	861
Problems of Collective Motion in Physics. By Dr. D. ter Haar	866
Industrial Health in Britain	867
International Standards for Drinking-Water. By Dr. E. Windle Taylor	867
The Weizmann Institute of Science	868
The British Flora during 1958. By J. E. Lousley	869
Linear Transfer of a Potentially Mutant State in Bacteria. By Dr. F. Kaudewitz	871
Liquid Crystals of Lipid in Normal and Atheromatous Tissue. By G. T. Stewart	873
Trichloracetic Acid-insoluble Phosphate Compounds in Cartilage. By R. G. Whitehead and Dr. S. M. Weidmann	876
Prealbumin as a Complex in the α-Globulin Fraction in Human Serum. By Dr. J. R. Tata	877
Recent Scientific and Technical Books	Supp. vi

(Continued overleaf)

An

INFRARED DETECTOR

sensitive from Visible to Microwaves

The operation of the Golay Detector is based upon the expansion of a gas of low thermal conductivity in contact with a non-selective heat absorbing membrane. The cell in which the gas (normally Xenon) is sealed has at one end a mirror membrane operating in a photoelectric amplifier system in such a way that the light intensity at the photocell varies directly with the gas expansion.

One of the major advantages of this system is a uniform sensitivity over a wide range of wavelengths. With suitable window material the Detector can be used to measure radiation intensities from visible light out to the microwave region. The adjoining table shows recommended window materials for specific wavelength regions.

The Detector can be delivered from stock with the following windows — KBr, Quartz, KRS-5, CsBr.

We shall be pleased to quote for alternative windows, for the Detector alone or for the full equipment including electronic and chopper units.

TABLE OF WINDOW MATERIALS

Material	Approximate useful wavelength limits
KBr	from visible to 26 μ — 27 μ.
CsBr	,, ,, ,, 35 μ — 40 μ.
CsI	,, ,, ,, 45 μ — 50 μ.
Quartz (0.25 mm thick)	,, ,, ,, 3.5 μ and from 45-50 μ to microwaves.
*Arsenic trisulphide	,, ,, ,, 10 μ.
*KRS-5	,, ,, ,, 35 μ.

*These two salts are non-hygroscopic but introduce some energy losses.

UNICAM

GOLAY INFRARED DETECTOR

UNICAM INSTRUMENTS LTD · ARBURY WORKS · CAMBRIDGE

U 165

LETTERS TO THE EDITORS

Page

CRYSTALLOGRAPHY

Crystal Structure of Calcium Thymidylate.—P. Horn, Dr. V. Luzzati and Dr. K. N. Trueblood 880

PHYSICAL SCIENCES

A New Value for the Earth's Flattening, derived from Measurements of Satellite Orbits.—D. G. King-Hele and R. H. Merson . . . 881

Heat-Flow Values from the South-Eastern Pacific.—Dr. R. Von Herzen 882

Improvement of the Fatigue Strength of Notched Specimens by artificially induced Residual Stresses.—T. R. Gurney 883

Thermal Decomposition of Irradiated Solids.—Dr. E. G. Prout 884

Errors caused by Partial Drying of Hardened Portland Cement during Testing.—Dr. K. M. Alexander 885

CHEMISTRY

Structure of Glass.—Prof. I. Náray-Szabó . . 886

Estimation of Strontium in Animal Bone using X-ray Fluorescence Analysis.—W. M. B. Roberts 887

Micro Determination of Calcium.—A. B. Gilbert 888

BIOCHEMISTRY

Production of Amide Groups and Ammonia in the Radiolysis of Aqueous Solutions of Protein.—Dr. Winifred Bennett and Dr. Warren M. Garrison 889

Anion Inhibition of α-Glycerophosphate Dehydrogenase.—Dr. Otto Z. Sellinger and Dr. O. Neal Miller 889

Flavan-3.4-diols and Leuco-anthocyanidins of *Guibourtia* spp.—Dr. D. G. Roux . . . 890

ANIMAL PHYSIOLOGY

Chlorothiazid in Diabetes Insipidus.—Dr. J. D. Crawford and Dr. G. C. Kennedy . . . 891

Changes in the Group *A* Antigen in a Case of Leukæmia.—Dr. E. R. Gold, Dr. Geoffrey H. Tovey, W. E. Benney and F. J. W. Lewis . 892

Absorption of Radioiodine through the Bladder-Wall in the Rabbit.—Oskar Andrysek and Ota Schück 893

Disturbance in the Pattern of Serum Proteins in Experimental Atherosclerosis and its Prevention.—Prof. M. C. Nath, A. Saikia and B. I. Uppin 894

Study of Adenovirus Antigens by Immunoelectrophoresis.—Dr. H. G. Pereira, Dr. A. C. Allison and Dr. C. P. Farthing 895

Effect of Tranquillizing Agents on the Resistance of Rats to Histamine Stress.—Dr. Arthur M. Sackler, Dr. A. S. Weltman and Dr. Raymond R. Sackler 896

Slow Contraction of Smooth Muscle produced by Human Plasma.—Dr. Yousry Gabr and Raga H. Aly 897

Page

Barbiturate Nystagmus and the Mechanisms of Visual Fixation.—C. Rashbass . . . 897

Inhibition of Sensitiveness to Nicotine of Rabbit Aorta by Reserpine, Hexamethonium, Er' vl Flavone-7-Oxyacetate and Other Compou —Dr. I. Setnikar and M. Ravasi . . 898

PLANT PHYSIOLOGY

Absence of Gibberellin-like Substances in Filtrates of *Marasmius perniciosus* Stahel (Witch Broom Disease of Cacao).—W. F. Dudman and R. Nichols 899

Interaction of Magnesium and Adenosine Diphosphate in Photosynthetic Phosphorylation.—J. B. Mudd 900

Synergistic Effect of Zinc and Gibberellin.—Dr. John Dancer 901

MICROBIOLOGY

Endogenous Metabolism of Freshly Harvested Cells of a Brewer's Yeast.—V. E. Chester . 902

Allyl Alcohol as a Nutrient for Micro-organisms.—H. L. Jensen 903

Mode of Division of Pediococci.—Dr. Helge-Liane Gunther 903

A Gram-negative Sporing Bacterium from the Rumen.—Dr. P. N. Hobson and M. R. Purdom 904

GENETICS

A New Physical Method of creating Chromosomal Aberrations.—Dr. John H. Heller and Dr. A. A. Teixeira-Pinto 905

Preliminary Information on the Genetics of Ethiopian Coffees.—Dr. Alcides Carvalho . 906

BIOLOGY

Generic Nomenclature of the Intermediate Hosts of *Schistosoma mansoni*.—Dr. C. A. Wright . 906

Effect of Gamma-Radiation on Weeds.—H. J. M. Bowen and S. R. Smith 907

Seasonal Changes in the Brain-case of the Common Shrew (*Sorex araneus* L.).—Peter Crowcroft and Jean M. Ingles 907

Entry of Spermatozoa into the Fallopian-Tube Mucosa.—Dr. C. R. Austin 908

An Abnormality in the Skin of Sheep.—Mary Dempsey and G. H. Green 909

Abnormal Resistance of *Poria vaillantii* (D.C. ex Fr.) Cke. Strains to Copper–Chrome–Arsenate Wood Preservatives.—E. W. B. Da Costa . 910

Density-Dependent Factors in Ecology.—Prof. G. C. Varley; A. J. Nicholson 911

Fossil Reptiles from the Panchet Beds of India.—L. B. Tarlo; Dr. Pamela Lamplugh Robinson . 912

ENTOMOLOGY

Proepithelial Regeneration in the Midgut of Beetles.—M. Ameen and Dr. S. A. Shafiq . 913

Respiration of Corixidae (Hemiptera–Heteroptera).—Dr. Edward J. Popham 914

DIFCO *microbiological reagents and media*

Antisera and Antigens

Enteropathogenic Coli Klebsiella

Salmonella Shigella

Brucella Leptospira Streptococci

★

C Protein Antiserum and Standard

★

Infectious Mononucleosis Antigens and Standards

Over 60 years' experience assures UNIFORMITY · STABILITY · ECONOMY

Difco Laboratories

Prompt delivery from U.K. stock. Write for Difco Manual and technical leaflets to the sole agents:

BAIRD & TATLOCK (LONDON) LTD., CHADWELL HEATH, ESSEX, ENGLAND

Branches in London, Manchester and Glasgow *Agents throughout U.K. and all over the world*

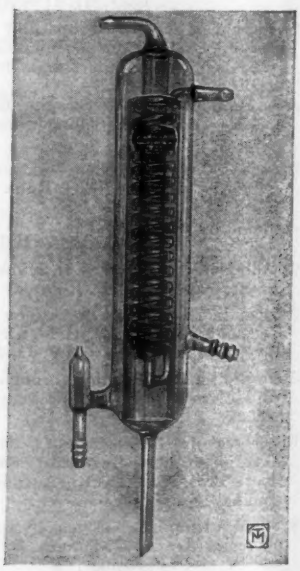
TAS/DO.9

ABOUT 20% REDUCTION IN PRICE

THE **STRIP ACTION** STILL

ALL GLASS—CANNOT FUR UP

Cleans and condenses steam *direct* from mains giving 1 gall./hr. per unit (batteries of 10 are quite normal). The distilled water is frequently purer than from most single pass water stills of conventional pattern.



NEW METHODS AND LARGER QUANTITIES
HAVE GREATLY REDUCED PRODUCTION COSTS

TOWNSON & MERCER LIMITED

CROYDON Telephone: THOrnton Heath 6262 ENGLAND

SCIENTIFIC AND TECHNOLOGICAL RESEARCH IN BRITAIN

IN its tenth annual report, the Advisory Council on Scientific Policy published estimates of the national expenditure in Britain on research and development in 1955–56, and of the man-power engaged in that effort, supplementing those given in the report "Scientific and Engineering Man-power in Great Britain" which was issued in the previous autumn. These estimates were based, so far as private industry was concerned, on the preliminary results of an inquiry conducted by Mr. E. Rudd, of the Department of Scientific and Industrial Research, to discover the cost of scientific research and technical development carried out by private manufacturing industry in Great Britain in 1955. The final results of this inquiry have now been presented in a White Paper* issued by the Department and setting forth the considered views of the Economics Committee of the Council for Scientific and Industrial Research. The chairman of that Committee, Prof. E. A. C. Robinson, contributes a foreword.

Prof. Robinson stresses three points. The figures are believed to give as reliable an indication of the scale and distribution of research expenditure in the main sectors of manufacturing industry in Britain as is possible to obtain in present circumstances; but the Committee is aware that estimates of research and development expenditure for individual industries more narrowly defined are subject to margins of error which increase with the extent of the subdivision. Secondly, considerable caution is necessary in reaching conclusions as to the adequacy or inadequacy of research in any particular industry. Frequently the research expenditure of an operating industry considerably under-estimates the volume of relevant research. Thirdly, research and development do not represent the only means by which science can be applied to industry, nor are the limits either of research or development easily and clearly definable. The application of science to industry occurs in departments concerned with design and the improvement of production, as well as in the research and development departments.

The man-power inquiry, carried out by the Social Survey on behalf both of the Department of Scientific and Industrial Research and the Ministry of Labour and National Service, sought information from all manufacturing establishments employing 500 workers or more, and from a sample of those employing between 100 and 499. The second part of the inquiry, which sought to relate man-power with expenditure, collected information from some 238 firms, and more detailed information was obtained from another 94 firms. All these firms volunteered the information, but although the industrial coverage was incomplete and the firms were not a statistical sample, it is believed that the average cost of £1,300 per person employed on research and development in private industry is reasonably accurate. When used, however, to estimate expenditure on research and development in all manufacturing industry, except aircraft, this figure probably leads to under-estimation rather than to over-estimation.

Under research and development, those replying to the questionnaires were asked to include basic and fundamental scientific research and also applied research, technical development and technical service work, including technical design work, done in connexion with different raw materials, or in introducing new working methods. Manufacturers were asked to include prototype production, but to exclude routine analyses, inspection, production, testing and quality control; detailed design of manufacturing units based on information supplied by research; tooling-up and similar preparation for full-scale production, after the development of new plant; and normal production for sale, market research and the selling of an established product.

The survey indicated that in 1955, 109,500 full-time workers were employed in Great Britain by private manufacturing industry on scientific research and technical development at a total cost of £183 million. Since manufacturing industry contributed £6,535 million to the gross national product, expenditure on research and development represented 2·8 per cent of this contribution; but nearly 44 per cent of this research development expenditure is accounted for by the aircraft industry, and this £80 million came largely from Government defence contracts. According to estimates of the Advisory Council on Scientific Policy, defence contracts contributed £118·4 million to research and development in private industry, and on that basis industry's own expenditure on research and development was less than 1 per cent of its contribution to the gross national product. Metal manufacturing and the engineering industries, including vehicles and aircraft, accounted for 77 per cent of the total expenditure on research and development, and the chemical industry, including mineral oil refining, for another 13 per cent.

According to the man-power survey, some 130,000 people are engaged on research and development in private manufacturing industry in Britain, but of these 37,662 are part-time; 35,215 full-time and 14,767 part-time are engaged in the metal manufacturing and engineering industries and 14,810 full-time and 7,138 part-time in the chemical industries. Of the total, 48,829 qualified engineers and scientists are employed in all manufacturing industries; of these, 14,855 scientists and 14,341 engineers are employed in research and development, engineers predominating in the metal-using indus-

* Department of Scientific and Industrial Research. Estimates of Resources devoted to Scientific and Engineering Research and Development in British Manufacturing Industry, 1955. Pp. 50. (London: H.M. Stationery Office, 1958.) 3s. net.

tries and scientists in the chemical industries, which employ 5,862, or more than two-fifths, of all the scientists engaged on research and development in manufacturing industry. The textile industries employed 765 scientists and 241 engineers on research and development, largely in the man-made fibre industries. The ratio of supporting staff averaged 1 : 3 for all industry and ranged from 1 : 7·5 for aircraft and 1 : 6 for other vehicles and components to 1 : 1·5 for the chemical industries and metal manufacture and 1 : 1 for food, drink and tobacco.

More than half the research and development workers covered by the survey were employed in 683 establishments employing 1,000 or more workers, and together totalling about 37,000 workers, and this average of 55 research and development workers per establishment compared with an average of five in the smallest establishments included in the survey. Moreover, 80 per cent of research and development workers were employed in the 309 firms with research and development staffs of more than 50, and the 2,031 establishments employing 10 or fewer persons in research and development only employed 8 per cent of the total. Afterwards it was estimated that 58 companies or groups account for about £60 million of the total expenditure on research and development in private industry in Britain.

Research and development expenditure as a percentage of the net output averaged 3·5 for all industries, or 2·0 excluding aircraft, and varied from 35·1 for aircraft, 6·8 for electrical engineering and 4·8 for chemical industries, to 0·2 for wood and cork and 0·1 for clothing. Per person it averaged £30 for all industry (or £17 excluding aircraft) and varied from £354 for aircraft, £70 for chemical industries, £56 for electrical engineering, £21 for precision instruments, jewellery, etc., to £0·3 for clothing. In addition to the £183·2 million spent by industry in its own research and development establishments, another £8·9 million is contributed from the research associations and from research stations of the Department of Scientific and Industrial Research, and in the shipbuilding and marine engineering industry this contribution amounts to 81 per cent of the expenditure on research and development. It exceeds 50 per cent in five other industries : boots and shoes (67) ; linen, jute, hosiery, knitwear and lace (61) ; wool and worsted (58) ; cotton (56) ; and the manufacture of wood and cork (55). In leather, leather goods and fur, it is 38 per cent, and in ceramics 32 per cent.

These figures obviously bear closely on the position of the research associations and indeed of the research stations of the Department of Scientific and Industrial Research, and will no doubt be carefully weighed by the Council of Scientific and Industrial Research in reaching its decisions as to the future of any particular research association or research station. Moreover, while it is desirable, for example, that a research association should receive the maximum support from the industry it serves, the best means of encouraging such support may well vary from industry to industry and depend considerably on the structure of the industry and the size of its units. The predominance of smaller firms may well make this a matter of considerable difficulty in view of the concentration of existing research activities in the larger firms, and added to this there is a widespread illusion among the smaller firms that the larger firms derive proportionately the greatest benefit from co-operative research.

This is possibly true in so far as a smaller firm employs no one capable of assessing the significance of scientific advance for its own activities, and in this connexion the expansion of Britain's effort in research and development is partly an educational problem depending on the supply of sufficient numbers not merely of well-trained scientists and technologists but also of those capable of appreciating the nature and value of scientific work. It is related to education for management in the broadest sense—to ensuring that those who enter industry are at least able to understand the dependence of industry upon technological advance and to make effective use both of the services of scientists and technologists and the new knowledge which is being placed at their disposal. No conclusions are drawn from the estimates in this White Paper, nor are any recommendations included ; but the Council for Scientific and Industrial Research and the Advisory Council for Scientific Policy must clearly proceed with great care at this juncture in determining their policy in regard to the research associations and to the research stations. A false step could do much to jeopardize expansion and an apparent immediate economy might prove to involve much wasted effort and greater expenditure in the long run.

The survey was concerned solely with private industry, and only to this extent touches on the research and development effort of the central Government. Even the adequacy of the industrial effort, however, cannot be assessed realistically without reference to the Government effort and to that of the universities and the independent research institutions. A broadsheet issued by Political and Economic Planning shortly after the White Paper was published (No. 430 ; January 19, 1959) provides a somewhat wider perspective, although it is limited to a survey of scientific and engineering man-power. This is a revised version of a paper written in 1957 by Mr. R. Fort for the Scientific and Technical Committee set up by the North Atlantic Treaty Organization's Conference of Parliamentarians. Although, like Mr. Rudd's survey, it draws largely on "Scientific and Engineering Man-power in Great Britain", it is supplemented by information obtained from the Office of the Lord President of the Council and, besides summarizing the present position of scientific and engineering man-power in the United Kingdom, it reviews briefly Government policy for increasing such man-power, possible improvements in the use of scientific and engineering man-power, trends in education and the content of education in science and engineering.

The survey of the present man-power situation adds little to that given in the last report of the Advisory Council on Scientific Policy. It points out,

however, that if we are to aim at about 20,000 young people a year graduating in pure and applied science by 1970, attention to the number of supporting technicians is imperative. The total number of technicians qualifying in 1957 was about 21,000, and this figure may be expected to increase as firms release more students to attend part-time day classes. It is, however, a long way below the figure of up to five or six for every fully qualified scientist or engineer; Mr. Fort's comment that, as more young people recognize the value of a formal qualification, the output from existing courses may have to be doubled to make sure that the numbers of technicians keep pace with the increasing numbers of qualified scientists and engineers, is more likely to be an under-estimate than an over-estimate.

No fresh suggestions for improvements in using trained scientists and engineers are made in the broadsheet, though a little stress is laid on the possibility of using more women scientists in industry. Mr. Fort points out, however, that there is scope for more men and women with scientific and technological training in responsible administrative and commercial posts, where their better understanding of the fundamental problems of the industry in which they work should contribute to greater efficiency and to higher productivity. This in itself accentuates the need for a higher output of scientists and engineers, and for doing everything possible to ensure that they are not employed on work which could be done just as well by technicians or other less highly qualified people.

As regards trends in education, Mr. Fort notes the high wastage among those leaving secondary technical and modern schools at fifteen or sixteen to enter industry and to attend evening courses leading to technician and craft certificates. Only about one in ten of those who start Ordinary National Certificate courses continue to success in the final examination. The wastage in part-time day courses is less, and the trend is towards increasing release for day courses; but it is estimated that 30,000 additional teachers will be required to provide for the increase in part-time day-release students which will result from the increased post-war birth-rate and the introduction of compulsory day-release. Here, again, Mr. Fort points out that the shortage of science teachers is the most serious aspect of the situation, and in discussing the content of education and the relation between school and university education he notes that perhaps one third of the boys and girls in schools are undecided in their preference of science or the arts.

To increase the supply of scientific man-power, therefore, school curricula should be drawn up so as to encourage pupils to decide to take science, while avoiding over-specialization; and university entrance standards should make it as easy as possible for the schools to strike the balance between giving a broadly based education and encouraging the undecided to take science. More specifically, Mr. Fort notes that many pupils at school seem to be discouraged from taking science by their failure to master enough mathematics, and this failure suggests that the methods of teaching may be faulty. Indeed, the most positive contribution of the broadsheet is perhaps its suggestion that at the heart of the whole problem of expanding scientific and technological man-power is the provision of more science teachers in schools; and that attracting more pupils to take science first in the schools and then in the universities, and improving the teaching of mathematics are probably the two most promising steps for providing more such teachers. The first of these comments strongly underlies Dr. Kenneth Hutton's forthright speech at the North of England Education Conference at Scarborough and the Government's dilatoriness in dealing with the three critical factors on which the improvement of science teaching depends.

These two surveys thus demonstrate how interlocked is the whole question of scientific and technological man-power in Britain and our effort in research and development with education generally. They indicate once again the danger of determining policy in any particular sector without reference to repercussions elsewhere. They do not suggest that the present target for scientific and technological man-power is inadequate, but they throw little light on how the redistribution of present or future effort should be effected. The adequacy or inadequacy of research and development in a particular industry can be assessed only by reference to the organization of that industry and its essential characteristics and to the magnitude of the country's effort in fundamental research and the effectiveness of communications. The survey of industry's own effort needs to be supplemented by a corresponding survey of research and development in Government establishments, and by yet another survey of fundamental and applied research in the universities, colleges of technology and in independent research institutions. Moreover, even when the relative magnitude of the effort in terms both of money and of man-power in these different sectors is known, we need to know more about the efficiency with which it is conducted and the adequacy with which the scientist and technologist is supported with equipment as well as with technicians and craftsmen.

It is now more generally recognized that research in the universities needs much more generous support in these respects, but the distribution of fundamental research as between the universities, the independent research institutions, the research associations and the research stations of the Department of Scientific and Industrial Research deserves much more attention. It cannot wisely be decided without clear conceptions as to the functions of these various institutions and the relation of such research to their other functions. Any changes in the work of the Department of Scientific and Industrial Research should follow and not precede such conceptions. It does not, in fact, appear that the Council is as yet prepared to say how far the Department should engage in pure research even in its own research stations, let alone how far the research associations should conduct such research; yet the answer given

to the latter question determines considerably the extent to which industries now served by the grant-aided research associations can be fairly expected to bear the full financial responsibility for the research associations.

Again, even if the Department's responsibilities for research of direct application to industry are determined largely by the extent to which further research is likely to be stimulated in industry, the extent to which the Department's own stations should engage in such research will not easily be decided without considering the further problem of how to allocate available resources effectively in order to meet the demands which team-work and highly expensive equipment now make. The Council, in its first annual report, indicated that these questions were already being considered. Its second report will certainly be awaited with considerable interest and some anxiety; but in the meantime these surveys have done something to clarify the picture, and to indicate the points at which further information on the national effort is needed—and some at which action is urgently required—if only to check existing waste and to increase the effectiveness with which present limited resources in trained man-power or expensive equipment are used. Even while new policies are being devised, much could be done to make far more effective use of present expenditure and resources, given sufficient imagination, co-operation and drive.

THE FATHER OF CHEMISTRY

Robert Boyle and Seventeenth-Century Chemistry
By Prof. Marie Boas. Pp. viii+240. (Cambridge: At the University Press, 1958.) 30*s*. net.

DR. MARIE BOAS, assistant professor of the history of science in the University of California, gives an account of the achievements of seventeenth-century chemistry with Robert Boyle as the central figure. The foundation of his development as a scientist is doubtless his early interest in collecting medical recipes and preparing medicaments. He soon became an ardent experimentalist, using the "Book of Nature" as his teacher. He came to regard chemistry as "highly conducive to the true knowledge of Nature", and to be not only a necessary part but also a respectable and useful part of natural philosophy, able to "contribute to its advance as a whole".

The chemical and physical theories of matter current in Boyle's time did not satisfy him, and he developed a mechanical, corpuscular theory, based on experiment, by which he strove to banish all occult notions from natural philosophy. In "The Sceptical Chymist" he demolished the established theory of elements in its various forms, and ended by being doubtful of the existence of any elements. Dr. Boas points out the great difference between the concept of elements then and now, and stresses its importance for a proper understanding of seventeenth-century chemical theory and Boyle's objections to it. His rejection of the old view of a chemical element paved the way for the concept of simple substances, which led ultimately to the new definition of element. His firm belief in corpuscular philosophy apparently provides the explanation of his belief in transmutation, since he considered the change from one metal to another to involve merely a change in corpuscular structure.

The increase in the number of substances resulting from experimental work inevitably raised the problem of chemical composition. Throughout this period the attempt was made to improve chemical nomenclature, basing it on chemical entities instead of imaginary elements or principles. Chemical reactions presented great difficulty, and only gradually came to be regarded as a combination or an interchange of chemical entities. The method of analysis by fire frequently gave very good results, but difficulties in interpretation arose from the confusion caused by variations in experimental technique, and inaccurate nomenclature. Chemical identification tests were greatly extended in scope by Boyle, who evolved precipitation tests, colour reactions, flame tests, and indicators for alkalis.

At an early date Boyle interested himself in chemical classification. His successful classification of acids, alkalis, and neutral substances killed the acid-alkali theory of matter. He recognized that acids had two parts: one that caused all acids to give a colour change with an indicator; the other that made one acid different from another. He was not so successful in his attempts at nomenclature for salts. Boyle's experiments on air are discussed. He could not "believe that the elastic particles of the air are really chemical entities", and he regarded fire, rather than air, as the chief agent responsible for calcination, and the increase in weight of metals.

Boyle's scientific method and experimental technique are discussed in the final chapter. His writings are prolix and frequently tedious; his method of preserving the records of his work prior to publication was haphazard, if not careless; but in contrast to this his experimental work was carefully conceived, detailed, and properly noted at the time. He was a shrewd observer, and no stranger to the use of quantitative methods, even if he was not as accurate with them as he could have been, and at times failed to interpret the results correctly.

The bibliography adequately covers the subject. The index, too, is adequate, but curiously omits all mention of any of the works of Boyle discussed in the text. For references to Boyle's life the octavo edition of 1744 has been used, and for his works the folio edition of the same year. From the point of view of accessibility the quarto edition of 1772 would perhaps have been a better choice for both purposes. Some of the references to the archives of the Royal Society are confusing because the system of nomenclature used by that body has not been adopted. The following corrections, among others, may be noted: p. 9, Boyle returned to England in mid-1644, not in 1645; p. 11, *Add. MSS* 4316 should be 4314; p. 24, Gerard Boate died in 1650, not 1653; and "Ireland's Naturall History" was published under his name as sole author; p. 30, Boyle was in Ireland by the last week of June 1652; p. 211, the reference should read "Royal Society. Correspondence. Early Letters. Guardbook B.1. 100", and the date of the letter is "9 Dec" not "2 Dec". These, however, are minor errors, and in no way detract from the brilliance of this important book, in which Dr. Boas, with a skilful marshalling of widely distributed facts from Boyle's works and papers, conducts the reader in virtuoso manner through the labyrinth of seventeenth-century chemical thought and practice.

R. E. W. Maddison

PLASTICS FOR THE PRACTICAL MAN

Polyurethanes

By Bernard A. Dombrow. (Reinhold Plastics Applications Series.) Pp. ix+176. (New York: Reinhold Publishing Corporation; London: Chapman and Hall, Ltd., 1957.) 4.50 dollars.

Polyamide Resins

By Don E. Floyd. (Reinhold Plastics Applications Series.) Pp. viii+230. (New York: Reinhold Publishing Corporation; London: Chapman and Hall, Ltd., 1958.) 4.50 dollars.

Plastic Sheet Forming

By Robert L. Butzko. (Reinhold Plastics Applications Series.) Pp. ix+181. (New York: Reinhold Publishing Corporation; London: Chapman and Hall, Ltd., 1958.) 4.50 dollars.

Cellulosics

By Walter D. Paist. (Reinhold Plastics Applications Series.) Pp. xi+270. (New York: Reinhold Publishing Corporation; London: Chapman and Hall, Ltd., 1958.) 5.75 dollars.

Fluorocarbons

By Merritt Allen Rudner. (Reinhold Plastics Applications Series.) Pp. x+238. (New York: Reinhold Publishing Corporation; London: Chapman and Hall, Ltd., 1958.) 5.75 dollars.

"THE Modern Plastics Encyclopedia" for 1958 lists 102 books on plastics and high polymers published since 1950. To this literature, a new series of monographs has been added (Reinhold Plastics Application Series) of which six have been issued while ten more are in preparation. Their appearance coincides with a recent decision of the Plastics Institute to make its set of eleven titles in the Plastics Monograph series available to the public through an arrangement with Messrs. Iliffe.

Any protest at this profusion of books on plastics must be tempered by the awareness of much disagreement existing between the experts as to the very nature of plastics as displayed at the recent Polymer Tribunal. In any event, any new book may be welcomed if it largely comprises new material or a novel presentation, and it is in this spirit that the present series may be reviewed.

In "Polyurethanes", a brief account of their chemistry is followed by chapters on foams, rubbers and surface-coating and adhesive applications. The book makes clear which are the commercially important raw materials and the manner in which the systems function in diverse applications. It contains a useful account of polyurethanes derived from castor oil, and hindered and reversible systems and, despite the absence of serial references, should have a reasonably wide appeal.

"Polyamide Resins" is written with a chemical slant, and serial references are given to published work. The book contains little that is new about fibre-forming polyamides and may be valued principally for the information it gives on the novel 'Versamid' dimeric fatty acid/polyalkylene amine polyamides and their blends with epoxy resins, with which the author is specially familiar by virtue of his association with General Mills Inc.

The reader of "Plastic Sheet Forming" will be impressed with the scope of this versatile technique by the long list of applications assembled. Nineteen variations of the process illustrated by easy-to-follow diagrams and an account of commercially available equipment, including cost estimates, makes it possible to recommend this as a very useful practical guide to those contemplating the use of the sheet-forming process.

In contrast with the three books listed above, the author of "Cellulosics" has had to deal with a subject in which there is a very considerable literature. The presentation ranges from fabrication techniques for spectacle frames to the dyeing of woven fabrics. In attempting to cover all outlets for cellulose and its derivatives, the book is of proportionately reduced value to the student of plastics. Neither references nor a separate bibliography are given. Table 3.5 requires correction.

The title of "Fluorocarbons" is somewhat misleading, for the book contains no mention of materials other than polymers of tetrafluorethylene and monochloro trifluorethylene. Even on these, there is little information not normally available from sales and technical bulletins. The term molecular weight is often used in the wrong sense, and a chapter on the chemistry of fluorocarbons (written in collaboration with Claude Bunnell) is marred by misprints.

In an ostensibly uniform series of monographs, a bad impression created by any one book tends to prejudice the reader against the remainder of the series. Such a temptation should be resisted and, as this review shows, each monograph should be appraised on its own merits. One overall criticism, which is often made in regard to American publications, is that the price per book will be considered high in Britain in relation to the value. S. H. PINNER

MAMMALIAN HAIR

The Biology of Hair Growth

Edited by William Montagna and Richard A. Ellis. Pp. xvii+520. (New York: Academic Press, Inc.; London: Academic Books, Ltd., 1958.) 15 dollars.

THIS book, equivalent to proceedings of the Conference on Hair Growth held in London in 1957, is a revelation of progress and promise. Those working on hair will need no encouragement to keep this book always at hand. It reports a modern breakthrough, by new techniques and experiment, largely in young branches of old sciences, often concerned with very minute structure and tiny quantities. Hair is very favourable material for relating biochemistry to morphology. Though much remains to be discovered, Montagna may reasonably claim, after surveying recent advances which emphasize how precise is the control of the intense activity of the follicle, that "the understanding of the prime forces that guide and control hair growth cannot be far off".

As an organ, the hair follicle corresponds in convenience with Protozoa among animal types, and examples follow of phenomena and principles of which bio-scientists in other fields may care to take note. Cell division is an all-or-none reaction, and even the death of the animal does not arrest it (Bullough, on mitosis). Some treatments inhibit initiation of growth, but have no effect on follicles already growing (Mohn, and Montagna's summary). An intricate balance of many hormones is required for the normal occurrence of the periodic waves of spontaneous replacement in the rat (Mohn). The response of follicles to treatments depends on the phase of the

growth-cycle in rodents, and in man (Van Scott). The presence of growth-waves in the rat, and their absence from the guinea pig, are probably related to *vascularization (Durward and Rudall)*. *In fibro*-genesis the same end-result is evidently reached by different routes (Mercer). Reduction of the size of the follicle in catagen is retrograde morphogenetic transformation, not degeneration in the usual sense *(Montagna and Van Scott)*. *The idea that the cell* components may first dissociate and then reunite is a contribution to thought on the mode of working of the gene (Rothman).

Practical application is being sought chiefly in the extremely odd coats of fleece-bearing sheep and man, which both pose fascinating problems in evolution. As to wool, more reciprocal trade is desirable between mouseries and both farms and mills. With reference to human cancer, all that will be said here is that work on the inheritance of coat colour in rodents half a century ago was research now related to human cancer *(Fitzpatrick et al., p. 279)*. *A still more widespread* killing disability in the human race is maleness. Apparently there is a spectrum in which tendencies to highly developed secondary sex characters merge with tendencies to sex-selective pathological states, *rapid aging, and short duration of life (Hamilton,* p. 431). Any new fact about hair may save male life and wits.

In gratitude to the late Prof. Walter Garstang this opportunity is taken to report that he coined the *terms for growth-phases, anagen, catagen, telogen,* and the names of the fibre types monotrich, awl, and auchene, in one short discussion. For the fourth fibre type he then proposed ptychotrich, but a few days later substituted zigzag. F. W. Dry

THEORETICAL PRINCIPLES OF ORGANIC CHEMISTRY

Theoretical Principles of Organic Chemistry

Vol 2. By Prof. Walter Hückel. Translated from the corrected 7th German edition by Prof. F. H. Rathmann. Pp. xi+1046. (Amsterdam: Elsevier *Publishing Company; London: D. Van Nostrand* Company, Ltd., 1958.) 95*s*.

THIS completes the translation of Prof. Walter Hückel's text-book, the first volume of which was reviewed some three years ago (*Nature*, **176**, 991; *1955*). *It was concerned in part with valency theory* and stereochemistry, dealt with under the heading of chemical statics; and in part with structural rearrangement and the chemistry of unsaturated compounds, dealt with under the heading of chemical dynamics.

The present volume deals with constitution as it determines physical properties and reaction velocities. Under the former heading are considered, *inter alia*, thermodynamic, electrical, and optical properties; *relations* between cohesion and constitution; properties of organic colloids and crystals; and the nature of the chemical bond. Under the latter are considered general theories of reaction velocity, and their applications; particularly to the hydrolysis of esters, to aromatic substitution, to polymerization, and to ring closures. Equilibrium constants for acidic dissociation, for ring closures, and for reversible oxidation-reduction processes are also considered briefly.

This volume, like the first, is well printed and produced. But it is tediously written, it contains many infelicities of translation, and *it gives far too much* prominence to out-moded and incorrect theories. Its treatment of electrophilic aromatic substitution *is particularly* confusing and disordered. An attempt is made to contrast the qualitative electronic theory with the *quantum-mechanical treatment attributed* to Wheland and to Seel. It is stated, for example (p. 800), that the latter theory "makes unnecessary the assumption of postulated hypothetical effects". The reviewer considers that the author has appreci*ated incompletely not only the part played by* factors of polarizability in the former theory but also the extent to which the "hypothetical effects" are concealed in the arbitrary assumptions of the latter. The reader will not be helped by Prof. Hückel's *discussion of the former theory through the* introduction of a "general effect", which deactivates for electrophilic substitution, but is identified strangely with Wheland's "polarization effect" and with Ingold's "inductometric (*sic*) effect".

Taken as a whole, the reviewer believes that these volumes will not generally be found useful by chemists familiar with other works available in the *English* language. P. B. D. de la Mare

AMERICAN MARINE LIFE

The Underwater Guide to Marine Life

By Carleton Ray and Elgin Ciampi. Pp. xiii+338+16 plates. (London: Nicholas Kaye, Ltd., 1958.) 30*s*. net.

THIS book about life in American coastal waters first appeared in the United States in 1956 and one wonders why an *English* publisher should have thought it suitable for the English market. Perhaps he is not aware that relatively few of the species described are to be found in European seas and that this book is of very limited interest to skin-divers (for whom it is primarily intended) on the eastern side of the Atlantic. His advertisements, one of them in a popular journal widely read by sub-aqua club members in Britain, certainly do not make any mention of this and in consequence are misleading.

The book, printed in the United States, is beautifully produced and attractively illustrated with many drawings and photographs, in both colour and black and white. It is true that the coloured drawings are sometimes not quite correctly tinted, but they are *reasonably* accurate in outline and will serve for identification, if not always for the species at least for the group. The *preliminary chapters give an* elementary account of the environment and of the general biology of the sea. The chapters on the *techniques* of underwater swimming and photography are too short to be really useful and the space they occupy could, *with advantage, have been* devoted to expanding the sections on plant life, and on the invertebrates which receive all too brief a treatment. The section on fishes occupies about half the book and is the most valuable portion of it. The final chapter deals briefly with marine reptiles and mammals. Apart from some minor errors of no great significance the book is accurate and well written, and should adequately serve its purpose as an underwater swimmer's guide to life on both coasts of the *United States, especially the warmer parts*. It should be very useful, too, to anyone visiting the magnificent marine aquaria and oceanaria of that country. D. P. Wilson

THE SOUTH AFRICAN COUNCIL FOR SCIENTIFIC AND INDUSTRIAL RESEARCH

By Dr. S. M. NAUDÉ
President

WHEN he was called upon in 1944 by the Prime Minister of South Africa, the late General Smuts, to draft legislation for the promotion of scientific research in the Union of South Africa, Dr. B. F. J. Schonland had the advantage of being able to study the successes and failures of a number of official research organizations both within the Commonwealth and in other countries, notably the United States. The basic Act under which the South African Council for Scientific and Industrial Research came into being in 1945 thus reflects many of the best features of research bodies in existence at that time. The South African Council for Scientific and Industrial Research has now functioned for some thirteen years, and, looking back, we are in a position to assess the success of that early planning.

One of the most important features insisted upon by Dr. Schonland, who afterwards became the first president of the Council for Scientific and Industrial Research, was that while adequate provision should be made for Parliamentary control, the day-to-day administration should be free of direct control by any Government administrative department. This was achieved by the establishment of a council of nine members (later increased to sixteen) appointed by the Governor-General on the basis of their personal reputation and achievement as leading men of science in the technical departments of the Government service, the universities and industry. The Council is responsible directly to the Minister of Economic Affairs, who in turn answers to Parliament, but the annual budget is subject to Treasury approval. In staff matters the Council is not bound by the regulations of the Public Service Commission, but in practice follows them closely. Over the years the Council has been reasonably successful in retaining its freedom of action, though from time to time it has had to resist pressure from departmental administrators.

Another important feature of the organization of the South African Council for Scientific and Industrial Research is that, as in the case of the Canadian National Research Council, the president is at the same time chairman and chief executive officer. This ensures on one hand that the policy of the Council is carried out expeditiously and, on the other, that no decision is taken without full cognizance of the administrative problems involved. As the Council normally does not meet more than three times a year, routine and urgent matters are dealt with by the president with the assistance of an executive committee the decisions of which are subject to ratification by the full Council. On the administrative side, the president is assisted by two vice-presidents, who attend Council meetings but have no vote. This arrangement places the president in a powerful position; but in practice it has worked extremely well to provide effective and purposeful execution of a policy laid down by the country's leading scientists, industrialists, educationists and technical administrators.

The terms of reference of the South African Council for Scientific and Industrial Research, covering the promotion of scientific research in general, are very wide, but they exclude agricultural research, which is the responsibility of the Department of Agriculture, and research in the social sciences, for which there is a separate council. In practice, demarcation between different fields of research is often artificial, and the Council co-operates closely with these bodies in such fields as industrial psychology and the industrial use of agricultural products which do fall within the Council's sphere of activities. In the absence of a separate body to deal with medical research, this, too, is the Council's responsibility, and, since 1956, it has also been responsible for the statutory functions of the former Standards Council, including the administrative control of the South African Bureau of Standards.

Policy

After detailed study of the conditions existing in the Union of South Africa at the close of the Second World War, the first Council decided that promotion of scientific and industrial research should be along four major lines:

(1) In order to provide the Government and industry with the basic facilities of modern scientific research, it would establish, equip and operate a limited number of national laboratories for both fundamental and applied research.

(2) It would offer inducement to industry to conduct its own research. This would take the form of remission of taxation of research expenditure, direct financial assistance to co-operative industrial research associations and the provision of facilities in its national laboratories for confidential research sponsored by individual firms.

(3) To ensure the rapid utilization of the results of research going on both locally and abroad, it would establish comprehensive liaison and information services, including a central scientific library and overseas offices.

(4) Finally, in order to ensure a steady flow of trained research workers, it would establish a system of postgraduate bursaries and research grants in the universities.

The fact that after some thirteen years of practical experience these still remain the corner-stones of the Council's policy bears testimony to the wisdom of this early planning.

Administration

The running expenses of the Council have risen steadily year by year and at present are of the order

Fig. 1. New buildings at Scientia, the research centre of the South African Council for Scientific and Industrial Research

of £2,450,000 a year. Of this, the Parliamentary grant accounts for approximately £1,760,000, the remainder being earned by way of remuneration for investigations carried out for industry, fees and grants from other sources. The Council's assets in the form of capital equipment amount to a total of about £1,800,000, while the current valuation of its buildings stands at £1,122,000. The latter figure represents approximately one-third of the current building programme which is expected to be completed in the course of the next few years.

At the time of its establishment in 1945, the Council had the greatest difficulty in recruiting trained research workers, for even in the universities little active research was in progress. However, a small nucleus of enthusiastic young scientists was recruited, and several of them were sent for periods of up to two years for specialized training in research institutions in the United Kingdom, the United States and, later, Europe. Around this nucleus it has been possible to build the permanent staff of the Council, which now numbers a little less than 2,000, of whom approximately 550 are graduates. The average age of the staff is thirty-one years, and the number of women members is just short of 25 per cent. It is interesting to note that, although vacancies are widely advertised overseas, it has proved possible to recruit the great majority of scientists in South Africa. Throughout the thirteen years of its existence the total number of research workers recruited overseas has not exceeded fifty.

The recruitment of adequately trained staff, however, still remains one of the principal problems with which the Council has to contend. Apart from the general programmes aimed at increasing the output of research workers from the universities, about which more will be said later, two specific training programmes have been adopted. The first of these, known as the Overseas Directed Research Bursaries Scheme, is aimed at increasing the supply of trained research workers in fields in which the shortage is particularly acute or for which no adequate training facilities exist in South Africa. Under this scheme, young graduates are awarded bursaries of £500–£1,000 per annum plus a travel grant to enable them to study a subject designated by the Council. The bursaries may be renewed from year to year on the recommendation of a referee, usually a senior member of the Council's staff, to whom the bursar is required to report at regular intervals. The bursar must undertake to return to South Africa on completion of his study. The other is an undergraduate scheme whereby promising students are granted bursaries according to their needs to enable them to attend full-time degree courses at a South African university. In return, they are required to sign an undertaking to accept employment with the Council for a number of years, depending on the total amount of the grant.

Standardization

One way in which the South African Council for Scientific and Industrial Research differs from similar organizations in other countries is that it also has responsibilities for the promotion of standardization in industry. Originally this was the responsibility of a separate Standards Council, which also operated extensive laboratories for testing and investigations aimed at the improvement of industrial processes. In 1956, however, it was decided to abolish the Standards Council and transfer its functions to the Council for Scientific and Industrial Research. The reason for the change was that research and standardization may be regarded as complementary means of promoting industrial development, and the work could be most effectively co-ordinated by a single controlling authority.

The existing South African Bureau of Standards was retained as the instrument for giving effect to the Council's policy in regard to standardization and is now operated as one of the national laboratories. The methods whereby standard specifications and codes of practice are drawn up in consultation with manufacturers, consumers, government departments and other interested bodies are similar to those adopted elsewhere, but it is worth mentioning that the work of the committees responsible for drawing up specifications is greatly facilitated by being able to draw on the resources not only of the technical staff of the Bureau but also of the Council's research laboratories.

The adoption of all specifications issued by the Council is entirely voluntary, except where the health or safety of the public is concerned or where gross malpractice is taking place. In such cases the Minister of Economic Affairs may declare a particular specification compulsory.

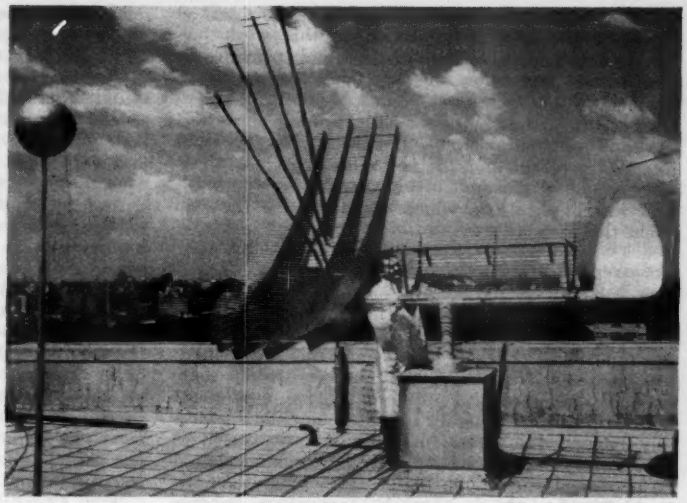


Fig. 2. Antenna display used by the South African National Telecommunications Research Institute in Johannesburg for research into the mechanism of lightning discharges

Linked with the preparation and issue of specifications and codes of practice is the standardization mark scheme, whereby a manufacturer producing articles in accordance with the requirements laid down in the specification may seek permission to apply one of the Bureau's marks to his product. The mark is protected by law, and quality is maintained by a regular system of inspection, sampling and testing in the Bureau's laboratories.

A further important service provided in the standards laboratories is general test work for consumers, public bodies and government departments. Normally, work which can be handled by private consultants and analytical laboratories is not accepted, but tests are undertaken for purposes of arbitration, together with a certain amount of forensic investigation on behalf of the police.

The services which the Bureau of Standards has been able to render industry have played a big part in the industrial development of South Africa. The expansion of our industries has proceeded largely by the introduction of established industrial practices and other adaptations to suit local conditions. Here the Bureau has been able to give a great deal of assistance by means of its testing facilities, by which it has been able not only to help manufacturers to procure raw materials and components against recognized specifications but also it has enabled them to assess the quality of their finished products and to compare them with equivalent products manufactured in other countries.

Research Laboratories

There are nine national research laboratories which conduct broad programmes of research, both fundamental and applied, aimed at providing the scientific information essential to the efficient utilization of the natural resources of South Africa. The National Chemical Research Laboratory, for example, has on its research programme a number of research projects which relate to raw materials or potential raw materials for South African industry. The National Physical Research Laboratory is responsible for maintaining South Africa's basic standards of physical quantities such as the units of measurement, heat, colour, sound and electricity; and is equipped to deal with specialized problems which require the use of physical techniques such as X-ray diffraction, electron microscopy, mass spectrometry and high-energy radiation. The problems involved in overcoming the critical shortage of housing at the end of the Second World War, together with those associated with the massive migration of native labour into urban areas to serve industry, led to the establishment of the National Building Research Institute, while the establishment of a large State-supported National Institute for Personnel Research to conduct research in the field of industrial psychology is a reflexion of South Africa's unique problems of man-power and human relations. This Institute developed out of research undertaken during the War for the Armed Services, as did the National Telecommunications Research Institute, which conducts research into radio propagation problems. Of more recent establishment are the National Institute for Road Research, the National Nutrition Research Institute, the National Mechanical Engineering Research Institute and the National Institute for Water Research.

The programmes of these laboratories are drawn up with the help of advisory committees and project sub-committees which advise the Council on the assignment of priorities. In recent years some of these advisory committees have been replaced by specialist advisers, who periodically investigate and report on the research programmes of sections of the laboratories. This system shows great promise, as it is at once less cumbersome and more effective than the committee system.

In addition to their normal research programme, these national laboratories perform a function similar to that fulfilled in the United States by the independent applied research foundations such as Battelle and the Mellon Institute. They undertake confidential research on a contract or fellowship basis

for industrial sponsors, who may be single firms or groups of firms. In recent years this work has assumed considerable importance and provides a substantial proportion of the Council's operating revenue.

In certain instances the research staff are permitted to spend up to 30 per cent of their time on 'personal interest' projects and, as is to be expected, these often result in research of outstanding quality with practical implications which could not be foreseen when the projects were initiated.

Research in Industry

However, it is the policy of the Council to persuade industry to undertake its own research wherever possible. In a relatively newly industrialized country like South Africa, research on a worth-while scale needing elaborate and often expensive equipment and the services of highly trained scientists is generally beyond the means of individual firms; it is therefore essential that research of this kind should be organized on a group basis. To achieve this, the Council adopted a research association scheme similar to that developed by the Department of Scientific and Industrial Research in the United Kingdom.

To date, five associations, covering the leather, paint, fish processing, sugar milling and wool textile industries, have been formed. They are financed by annual subscriptions guaranteed for a minimum period of five years by the majority of firms in the industry concerned, matched by an approximately equal grant from the Council for Scientific and Industrial Research. Industrial contributions not guaranteed for the full period of five years also earn a Council subsidy but on a less generous scale. These industrial research associations are registered under the Companies Act as non-profit companies and are managed by boards of control on which the industrial contributors have majority representation. The research programmes are confined mainly to directed research problems of common interest to member firms, and to the solution of technological problems which arise in the day-to-day operations of individual factories.

An important feature of the research association scheme in South Africa is that all the associations are located at universities, one at the University of Cape Town, two at Rhodes University in Grahamstown, and two at the University of Natal in Durban. The directors have been accorded the status of professor by the universities concerned, and a close and fruitful relationship has resulted. All five associations have now run out of their first or second five-year guarantee periods, and the measure of their success may be judged by the fact that industrial contributions are still increasing both in number and amount.

Information and Liaison Services

Scientists and engineers throughout the world are slowly—perhaps too slowly—coming to realize that progress in science depends upon the intelligent solution of problems in the field of scientific and technical information. These problems are aggravated in a country in which centres of population are separated by great distances and in which there are no great libraries such as in Europe or North America. Whereas in older countries the main problems are concerned with making resources of scientific and technical information available to the users, in South Africa the more immediate need is to build up these resources.

One of the Council's first actions was thus to establish an advanced central scientific library to serve not only its own staff but also research workers throughout South Africa. A feature of this library is a very large collection of pamphlets and reports, each of which is fully 'processed'.

Associated with the library is an information service. This includes a technical and bibliographic inquiry service which is able to draw on the written word and the accumulated experience of scientists and engineers in the Council's laboratories. This is backed up by the Council's scientific liaison services in London, Washington and Cologne, through which the scientist in South Africa can draw on the resources of the great libraries of Europe and North America or get into direct touch with co-workers in other countries. There is a translation service, and other activities include the compilation and publication of the "Catalogue of Union Periodicals" and various scientific directories.

The Council shares with the Department of External Affairs the Government's responsibility for maintaining international relations in science. The Council's scientific liaison officers in London, Washington and Cologne are accorded the status of attachés to the Union's diplomatic missions in their respective areas and, in addition to reporting on the latest developments in the field of science, act as scientific advisers to the heads of the missions concerned. On behalf of South Africa, the Council adheres to the International Union of Scientific Unions and provides the secretariat for the South African national committees of its affiliated unions. It has, for example, been extremely active in organizing South Africa's participation in the International Geophysical Year.

University Research

The Council early realized that, if the new industries which had grown up during the Second World War and the new research organizations which had been established soon after it were to be adequately staffed, it would be necessary to augment the supply of graduates with advanced degrees from the universities. Unfortunately, South African universities have not been generously endowed by private individuals, industrial corporations and benevolent foundations as is often the case overseas, and in earlier years there was little demand for scientists trained in research. Consequently, most of their efforts were confined to undergraduate teaching and it was difficult for them to retain graduates and build up postgraduate schools. On its establishment, the Council took over the functions of the defunct Research Grant Board as the principal agency for the distribution of funds made available by the Government of South Africa for the promotion of scientific research in the universities, and immediately pressed for a substantial increase in the appropriation for this purpose. Increasing sums are being distributed in the form of bursaries to train postgraduate students in research techniques, to pay for assistants for more senior workers in their researches, for grants towards the running costs of specific programmes, for the purchase of major items of equipment not normally available in university laboratories, and for grants to assist in the publication of completed research.

The allocation is made by a series of selection committees on the basis of individual applications, but the funds are made available in the form of block grants to the universities, which are required to administer them. The Council has up to the present resisted requests from some of the universities for uncommitted lump sum grants rather than individual grants, because it feels that the limited funds available can be expended to the best advantage only on the basis of individual projects considered by a single authority which is in a position to assess the merits of each application in relation to others received from different universities. The universities are, however, strongly represented on all the selection committees.

Medical Research

The Council operates no laboratories of its own for medical research, but, on the advice of its Committee for Research in the Medical Sciences, makes a substantial financial contribution to work in this field.

An annual grant is made to the South African Institute for Medical Research and, in addition, the Council supports some twenty-one small units, groups and major projects in medical schools and hospitals in various parts of the country. The Council's approach in this case has been to single out particular research workers who have already established names for themselves in existing institutions and give them adequate facilities to continue and expand their work. In most cases the scientist continues to hold his appointment in the institution concerned, but the Council supplies additional staff to work under his direction and provides funds for running expenses and any equipment he may need. In this way the Council is assured that any project which it decides to support in the medical field will be led by an experienced and enthusiastic research worker who has already shown himself capable of producing results. On the other hand, should the project later prove to be unprofitable, there is no difficulty in closing it down. At present the Council supports research into the following subjects: amœbiasis, anæsthetic deaths, bilharzia, the biological effects of atomic radiation, the cardio-pulmonary and cardio-vascular systems, degenerative diseases and the problems of aging, dental diseases, endocrinology, heart diseases, human biochemistry, nutrition (four separate units each with a different approach), pneumoconiosis, the reactions of the skin to sunlight, tuberculosis and virus diseases (two units).

It is interesting to note that evidence laid before the du Toit Commission, which was appointed by the Government to recommend a future policy for medical research in South Africa, was overwhelmingly in favour of retaining and expanding the present system under the general control of the Council for Scientific and Industrial Research instead of establishing an independent council for medical research. The findings of this Commission await consideration by the Government.

Achievements

It is not easy to assess the value of research, for its results can seldom be expressed in units which can readily be understood. There are, however, a few yardsticks which give at least some idea of what has been achieved.

One of these is publication. Some 800 scientific papers have now been published by staff members in the laboratories of the Council for Scientific and Industrial Research, and 300 have come from medical research units of the Council. To these must be added a further 550 which have flowed from the recipients of bursaries and grants from the Council.

Another yardstick, one which perhaps appeals most to the business man, is finance. We have not attempted to arrive at an exact estimate of the monetary value of the work we have done; this would be impossible, but our rough calculations convince us that actual savings brought about as a result of work done to date in our laboratories have more than covered the total amount spent by the Government on the Council for Scientific and Industrial Research, including the cost of buildings and equipment. As these savings have been brought about for the most part within the past few years as results began to flow from the laboratories, it is obvious that the annual savings will far exceed the annual costs of running the Council. Indeed, we estimate that the measurable savings to South Africa next year will be approximately seven times our parliamentary grant. As a concrete example, we could quote the case of research undertaken by the National Building Research Institute into the design of school buildings on behalf of the Transvaal Provincial Administration. The cost of this investigation was £20,000, and the cost of four of the schools in which the results of the research have been applied within the past two years amounted to £112,000 less than the Education Department would have had to pay had they been built to the old standard pattern with inferior accommodation and facilities. Several other examples, equally impressive, could be quoted.

Discoveries and inventions by the Council's staff are patented only if it is considered that the patent will aid in development of the inventions and thus in application of the results of research. Applications have nevertheless been filed in respect of some thirty-seven inventions. Revenue in the form of licence fees from the few inventions that are now being exploited at present amounts to about £50,000 a year and is increasing rapidly. This is ploughed back into research. Among the more successful of such inventions are the 'tellurometer', which is now being manufactured in South Africa and finding wide application for distance measurement in many parts of the world, and a water desalting process which is being used in the largest plant of its kind in the world on the new Orange Free State goldfields.

These, however, are but the more material results of research due to the Council for Scientific and Industrial Research. Of far greater importance in the long run are the immaterial benefits such as improved health and human comfort, greater productivity in industry and ultimately, we hope, a more contented people. In the universities we now see research being tackled with enthusiasm where practically no research was done before, and in industry we now attempt to solve our own problems where previously we were content to accept without question the dubious applicability under local conditions of technical knowledge imported from overseas. In short, South Africa is becoming conscious of the immense benefits to be derived from the intelligent use of science. This, we claim, is in no small measure due to the activities of the Council for Scientific and Industrial Research.

THE NUCLEAR RESEARCH CENTRE, GRENOBLE

THE Nuclear Research Centre at Grenoble, a further establishment under the control of the French Atomic Energy Commission, was officially opened on January 26.

The creation of this Centre under the French Government's general policy of decentralization is a further step towards increasing the research facilities of the French Atomic Energy Commission.

The Grenoble Centre (C.E.N.G.) will operate in close liaison with the city's University, which possesses laboratories in several branches of science of considerable repute (electrostatics and metal physics, science of low temperatures, fluid mechanics, chemistry, electronics, and so forth) plus excellent engineering faculties, and in particular a special atomic engineering course.

The director of the Centre, Prof. Louis Néel, member of the Paris Academy of Sciences, is also director of the Ecole Nationale Supérieur d'Ingénieurs of Grenoble and the Electrostatics and Metal Physics Laboratory of the Centre National de la Recherche Scientifique.

The first construction programme for the Nuclear Research Centre at Grenoble was completed in two years, on an extensive site close to the city. The programme comprised a number of modern laboratories suitable for a wide variety of research work, two large hangars of industrial type for noisy or bulky experiments, workshops and general services buildings. Facilities comprise the reactor *Mélusine* and a group of five electrostatic accelerators. *Mélusine* owes its name to a water sprite, which according to local tradition haunted the caves of Sassenage, near Grenoble. It is a 20 per cent enriched uranium pool reactor, of 1,200 kW. power, neutron flux 10^{13} neutrons/cm.^{2}/sec. It was built by the French industrial group "Indatom", and the fuel elements are obtained from the United States.

The accelerator building will be equipped in April with one fast neutron generator and four electrostatic accelerators (two ion accelerators, two electron accelerators) with potentials ranging between 600 kV. and 1·4 MV. Their special characteristic is a very high particle current (4 m.amp. with the 1·4 MV. ion accelerator) obtained with a type of electrostatic generator designed in one of the laboratories of the University of Grenoble, and built by the S.A.M.E.S., a company specializing in electrostatic machines.

The research programme of the Grenoble Centre is distributed over a number of 'laboratories'. Research in physics includes the activities of the solid state physics laboratory, where the effects of neutron bombardment on matter are studied, in close conjunction with the low-temperature laboratory, ex-

Fig. 1. Laboratory buildings at the Centre d'Etudes Nucléaires de Grenoble

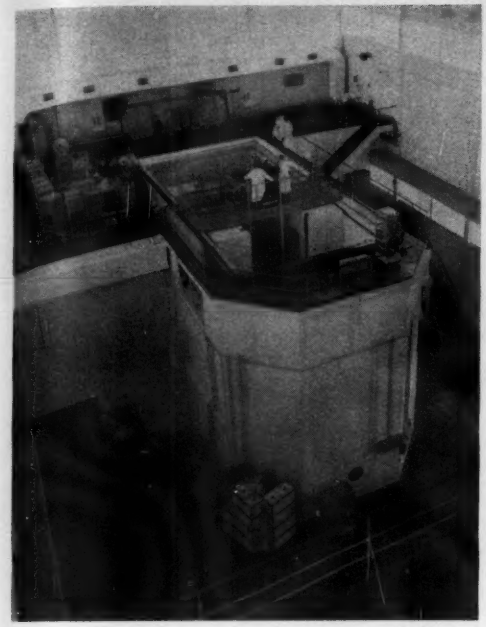


Fig. 2. Swimming pool reactor *Mélusine*

tending this research into the range of 20–900° K., and also the work of the neutron diffraction and magnetic resonance laboratories.

A radiochemistry laboratory has been installed in the Centre by the French Petroleum Institute, while the chemistry of solids laboratory is working on the production of a uranium compound for nuclear fuel elements.

There are, of course, also electronic laboratories, others for the study of applications of radioelements, and biology and nuclear physics laboratories, and also the thermal exchange laboratory, where heat exchanges with liquids in a reactor are studied.

The Centre's research programme is prepared by a scientific committee composed of six representatives from the Atomic Energy Commission and six professors from the University of Grenoble, who are scientific advisers to the Centre. This ensures the essential co-ordination with the programmes of other Atomic Energy Commission research centres.

As from January 1, the research work of the Centre is employing 300 persons. Construction is continuing, and the total staff by the end of 1961 will be 800.

In order to help in obtaining the required number of staff, the Centre collaborates with the organizations entrusted with the training of technicians at all levels. It is also pleasant to note that the Centre is situated in a region that is both industrial and of tourist interest, in the heart of the French Alps, and therefore considered particularly attractive by young technicians.

OBITUARIES

Prof. A. H. Gibson

Prof. Arnold Hartley Gibson, emeritus professor of engineering in the University of Manchester, died on February 16 at the age of eighty.

Those who have read Prof. Gibson's monograph on Osborne Reynolds will realize how much 'A. H. G.' admired his own teacher. That he shared some of Reynolds's versatility is clear from the fact that although he will best be remembered for his contributions to hydraulics, he also did significant work in structures (the 'circular-arc bow girder') and in applied thermodynamics (many papers on internal combustion engines and heat transmission). At one period he was simultaneously a member of the Air Ministry Engine Research Committee and of the Severn Barrage Committee.

In hydraulics, his investigations ranged from the behaviour of bodies floating in vortices to river models; from water hammer in pipes to the effect of bridge piers on tides; from centrifugal pumps to the interaction between passing vessels. His famous treatise "Hydraulics and its Applications" was published in 1908; the fifth edition appeared in 1952: he was then seventy-four years old and told me how much he would have liked to rewrite it, but he feared that in that case the price would have been beyond the reach of many for whom the book was intended. The chapter on scale models which he added is probably his last published work.

His writings have an unfailing clarity and directness, virtues which were also very evident in the unaffected elegance of his lectures. He knew just when to stop before confusing the issue.

Gibson's reports on the Severn tidal model (1933) have rightly been described as 'monumental' (an adjective which caused him some amusement). The scope and variety of the experiments—the trials on bed materials, the introduction of silt and the representation of the coagulating effect of the salts of the sea, together with the study of the tides and the bore—remain unsurpassed in this field, even allowing for the later growth in the size of models. His investigations of the Severn and other estuaries revived British interest in the possibilities of scale models as an aid to the design of river and harbour works and led to the creation by the Department of Scientific and Industrial Research of the Hydraulics Research Station at Wallingford.

Generations of students have held him in affection as well as admiration, and one reason for this is to be found in his own interpretation of the duties of a professor. His aim was to inspire and never to 'spoon-feed'. He not only believed that he ought to lecture to each year but also he enjoyed doing so. The course of twenty or twenty-five lectures which he delivered to students in their first term at Manchester, covering a wide field of applied mechanics, brought immediate contact, and this was renewed in the second and third years. At one time or another he lectured on almost every subject in civil and mechanical engineering. Yet in addition he took his full share in the general work of the University in Senate, faculty and committees and maintained his output of important original papers.

The fact that he was able to do so much can be partly explained by his gift for making quick decisions. As Prof. J. A. L. Matheson has written

elsewhere, "Gibson was a swift and brilliant intuitive worker. He could recognize a problem, build the apparatus, carry out the experiments and write up the results at a quite astonishing speed . . .". He was equally happy in guiding and encouraging his colleagues and research students. When he saw you baffled, he would blow a ring of tobacco smoke and say, "If I were you, I would try . . .".

Gibson enjoyed good books (which he read with a speed like that of his own writing) and works of art. He detested the pompous and the shallow equally. He sought no honours, but those intimate with him saw that he was made happy and proud by such distinctions as the Ewing Medal of the Institution of Civil Engineers and the honorary degrees of LL.D. conferred upon him by St. Andrews and Manchester. It is probably true, however, that the D.Sc. which he won at Manchester fifty years ago remained his favourite.

Naturally, his name is linked most prominently with the Beyer chair in his Alma Mater (1920–49), but he spoke with great affection of his period in Dundee as professor of engineering in the University of St. Andrews (1909–20, interrupted by service during the First World War in the Army and at Farnborough).

Perhaps no truer or more fitting tribute could be paid to 'A. H. G.' by those of us who had the happy experience of being his students and colleagues than to say that we feel the same veneration for him as he felt for Osborne Reynolds. Jack Allen

Prof. G. V. Douglas

George Vibert Douglas died suddenly in Toronto, Canada, on October 8, 1958, at the age of sixty-six. From 1932 until his retirement in 1957 he was Carnegie professor of geology at Dalhousie University in Halifax, Nova Scotia.

Prof. Douglas was born in Montreal in 1892. At McGill University he studied under F. D. Adams, but this training was interrupted by the First World War and he went overseas in 1915. He served in France and Flanders with the 17th Battn. Northumberland Fusiliers and, for a short time, with the Royal Engineers. He was awarded the Military Cross and mentioned in dispatches. He returned to Canada in 1919. He graduated from McGill in 1920 and received his M.Sc. degree in 1921.

He spent the next two years in the Antarctic as geologist with Shackleton's last expedition. While working up the results of the expedition, he was able to work in the University of Cambridge. This was followed by further work at Harvard University, where he held a part-time post as instructor under Daly. In 1926, he became chief geologist for the Rio Tinto Company—at first in Spain and later on the Rhodesian Congo Border concession. In 1932 he left the Rio Tinto Company to take up the post at Dalhousie which he held for the remainder of his active life.

Prof. Douglas was a notable factor in the lives of a whole generation of students. Undoubtedly his greatest influence arose from his ability to inspire enthusiasm and to encourage the student to do the best of which he was capable. A secondary influence was his own wide-ranging interest, and one recalls vividly the stimulus of an afternoon at his home, when ideas (some good, many otherwise, no doubt) flew like shuttlecocks as the teacher encouraged his students to exercise their wits. Ideas strongly held often plunged him into controversy but, though many disagreed, there were none who did not admit his courage and integrity.

He is survived by his wife, two daughters and two sons, and by his sister, Dr. A. V. Douglas, of the Department of Astronomy, Queen's University, Kingston, Ontario. G. C. Milligan

NEW FELLOWS OF THE ROYAL SOCIETY

At a meeting of the Royal Society on March 19, the following were elected to fellowship of the Society:

Dr. G. H. Beale, senior lecturer in genetics in the University of Edinburgh (Institute of Animal Genetics), distinguished for his researches on the genetics of flower pigments and on nucleus–cytoplasm relations in *Paramecium*.

Prof. F. Bergel, professor of chemistry in the University of London, at the Chester Beatty Research Institute of the Institute of Cancer Research, Royal Cancer Hospital, distinguished for his work in synthetical organic chemistry in the field of vitamins and drugs.

Dr. Ann Bishop, director of the Medical Research Council Group for Research in Chemotherapy, at the Molteno Institute of Biology and Parasitology, Cambridge, distinguished as a protozoologist and especially for her work on the malaria parasite and its resistance to drugs.

Prof. G. E. Blackman, Sibthorpian professor of rural economy in the University of Oxford (Department of Agriculture), distinguished for his research work on the ecology of wild and cultivated plants and on weed-killers.

Prof. H. Bondi, professor of applied mathematics in the University of London (King's College), distinguished for his contributions to cosmology, astrophysics and other branches of theoretical physics.

Prof. J. M. Cassels, professor of experimental physics in the University of Liverpool, distinguished for his studies of high-energy nuclear physics using particle-accelerating machines.

Prof. A. R. Clapham, professor of botany in the University of Sheffield, distinguished for his research upon many important aspects of ecology and taxonomy, especially those relating to British plants.

Dr. F. H. C. Crick, member of the staff of the Medical Research Council Unit for Research on the Molecular Structure of Biological Systems at the Cavendish Laboratory, Cambridge, distinguished for his contributions to molecular biology.

Mr. G. B. R. Feilden, director of research, Ruston and Hornsby, Ltd., Lincoln, distinguished for his application of scientific principles to the development and design of industrial gas turbines.

Dr. D. W. W. Henderson, director of the Ministry of Supply Microbiological Research Establishment,

Porton, Wiltshire, distinguished for his work on aerosols and the pathogenesis of air-borne infections.

Dr. R. D. Keynes, lecturer in physiology in the University of Cambridge, distinguished for his work on ionic movements in nerve and muscle and on the origin of the discharge in electric fish.

Prof. R. J. W. Le Fevre, professor of chemistry, and head of the School of Chemistry, in the University of Sydney, distinguished for his studies of the physical properties of organic compounds.

Dr. B. H. Neumann, reader in mathematics in the University of Manchester, distinguished for his contributions to the theory of groups.

Dr. S. R. Nockolds, reader in geochemistry in the University of Cambridge (Department of Mineralogy and Petrology), distinguished for his researches on the petrology and geochemistry of the igneous rocks.

Prof. W. C. Price, professor of physics in the University of London (King's College), distinguished for his contributions to chemical physics, especially to spectroscopy.

Prof. G. V. Raynor, Feeney professor of physical metallurgy and head of the Department of Physical Metallurgy in the University of Birmingham, distinguished for his research on the structure of metals and alloys.

Prof. O. W. Richards, professor of zoology and applied entomology in the University of London (Imperial College of Science and Technology), distinguished for his researches in entomology.

Dr. R. E. Richards, lecturer in chemistry in the University of Oxford (Physical Chemistry Laboratory), distinguished for his work on nuclear magnetic resonance and its application to chemical problems.

Prof. C. A. Rogers, Astor professor of mathematics in the University of London (University College), distinguished for his contributions to several branches of pure mathematics, particularly the geometry of numbers.

Prof. A. Salam, professor of applied mathematics in the University of London (Imperial College of Science and Technology), distinguished for his contributions to the theory of elementary particles.

Dr. R. Spence, chief chemist and head of the Chemistry Division, Atomic Energy Research Establishment, Harwell, distinguished for his work on the chemistry of radioactive elements, and for his leadership of the Chemistry Division of Harwell.

Dr. J. F. Tait, Worcester Foundation, Shrewsbury, Massachusetts, U.S.A., distinguished for his work on the hormones of the suprarenal cortex.

Mrs. S. A. S. Tait, Worcester Foundation, Shrewsbury, Massachusetts, U.S.A., distinguished for her work on the hormones controlling the distribution of salts in the body.

Dr. M. H. F. Wilkins, deputy director of the Medical Research Council Biophysical Research Unit, at the University of London (King's College), distinguished for his contributions to the development of reflexion and interference microscopy, and for his work on the structure of nucleic acids.

Prof. S. W. Wooldridge, professor of geography in the University of London (King's College), distinguished for his researches on the geomorphology of south-eastern England.

NEWS and VIEWS

The United Kingdom Atomic Energy Authority

The organization of the United Kingdom Atomic Energy Authority is to be changed as from July 1. Hitherto the Authority has been made up of three groups: the Research Group, the Weapons Group and the Industrial Group. The Industrial Group, which has become too large for convenient management, will now be divided into two: the Development and Engineering Group; and the Production Group. At the same time, the full-time technical members of the Authority will again assume executive responsibility for particular Groups, in addition to their functional responsibilities and general duties as members of the Board. Sir William Cook, with the title of Member for Development and Engineering, will be executive head of the Development and Engineering Group and will, in addition, retain corresponding functional responsibilities throughout the Authority. Sir Leonard Owen will have the title of Member for Production (Designate) and will be the executive head of the Production Group. Sir William Penney, whose appointment to succeed Sir John Cockcroft as the Member for Scientific Research has already been announced, will in addition become the executive head of the Research Group, while retaining his functional responsibilities for scientific research throughout the Authority. The appointment of a successor to Sir William Penney as Member for Weapons Research and Development will be announced later.

New Appointments

The following appointments have been made in the Research Group of the United Kingdom Atomic Energy Authority:

Mr. D. W. Fry, deputy director of the Atomic Energy Research Establishment, Harwell, to be director of the Atomic Energy Establishment, Winfrith (*Nature*, **182**, 1129; 1958).

Prof. F. A. Vick, professor of physics in the University College of North Staffordshire (*Nature*, **166**, 54; 1950), to be deputy director of the Atomic Energy Research Establishment, Harwell. During 1950–54 Prof. Vick was acting-principal of the University College of North Staffordshire. He is a member of the University Grants Committee.

National Research Development Corporation: Appointments

Mr. J. C. Duckworth has been appointed managing director of the National Research Development Corporation as from April 1 in succession to Lord Halsbury, who has been managing director since the formation of the Corporation in 1949 and is now going into industry. Mr. Duckworth, who is forty-two years old, took first-class honours in physics at

Oxford in 1938, and played a leading part in radar research and development during the Second World War. After the War, he was engaged in fundamental nuclear physics research at Chalk River in Canada and at Harwell, and was later in charge at Ferranti, Ltd., of development and design of the guidance and control system of the guided weapon now known as *Bloodhound*. In 1954 he joined the then British Electricity Authority with responsibility for the design, construction and operation of nuclear power stations, and is at present chief research and development officer of the Central Electricity Generating Board.

Mr. Dennis Hennessey has been appointed by the Corporation to a new post of deputy managing director. Mr. Hennessey, who was a former principal patents officer at the Ministry of Supply, joined the staff of the Corporation in 1950 at the age of thirty-eight and was made an executive member of the Corporation in 1956.

Government Research on Food Preservation

Three research stations of the Department of Scientific and Industrial Research, all concerned with the preservation, storage, handling or protection of foodstuffs, will be transferred to the Agricultural Research Council on July 1. They are the Ditton Laboratory at Larkfield, Kent, the Low Temperature Research Station at Cambridge, and the Pest Infestation Laboratory at Slough. The agreement between the Council for Scientific and Industrial Research and the Agricultural Research Council—announced in the House of Lords by the Lord President of the Council, Lord Hailsham, on March 4—was made because the two Councils consider that Government research on food other than fish would be more effectively pursued under one authority. The staff in the three laboratories, numbering about 200, will be invited to transfer to the service of the Agricultural Research Council.

Agriculture at Aberdeen: Prof. J. R. Raeburn

Dr. J. R. Raeburn, recently nominated to the Strathcona–Fordyce Chair of Agriculture at Aberdeen, in succession to Prof. A. B. Stewart, who has been appointed director of the Macaulay Institute for Soil Research (see *Nature*, 181, 1105; 1958), was educated at Manchester Grammar School, at the University of Edinburgh and at Cornell University. His career has been one of widely varied experience in research, teaching and administration. He did practical farm work in Scotland during 1928–29, and was engaged in research at the Edinburgh Animal Breeding Research Institute during 1932–33, before proceeding to his doctorate at Cornell. During 1936–37 he had the unusual experience of serving at the University of Nanking under Prof. Buck, whose collection of information on the subsistence agriculture of Chinese peasants is unsurpassed in any other such country. The agriculture of African and Asian peasants has been one of Dr. Raeburn's principal fields of research and teaching during his tenure of the readership in agricultural economics in the University of London since 1949. He has travelled extensively and has been much consulted by the Colonial Office on the development of its agricultural policy. During the Second World War he served in the Ministry of Food as secretary of the Home Agricultural Supplies Committee, the duty of which was to plan the development of home supplies in such a way as to give the maximum release of shipping space. During 1938–39 and 1946–49 he was a research officer at the Oxford Agricultural Economics Research Institute. At an early age Dr. Raeburn was recognized as an outstanding figure in his own fields of research. His work combines extensive knowledge and experience with subtle and sympathetic understanding of the difficult problems of decision which every farmer has to face, and strong criticism of some unreliable methods of sampling used in obtaining agricultural economic information.

The Jodrell Bank Radio Telescope

In replying on an adjournment debate in the House of Commons on March 4, in which Mr. R. E. Winterbottom and Lt.-Col. W. H. Bromley-Davenport had, while supporting the Committee of Public Accounts, pleaded for a more generous attitude from the Government in meeting the outstanding £140,000 on the Jodrell Bank Radio telescope, Mr. H. Nicholls defended the Government's attitude and, outlining the financial history in some detail, claimed that the Government from the first had given all the help it possibly could, within the limits of sound financial control, to this great project. Out of eight recent major university schemes costing more than £100,000 each which are being supported by the Department of Scientific and Industrial Research, three, including the Jodrell Bank project, had come under the ægis of the University of Manchester, and Mr. Nicholls did not think that the University had been treated ungenerously. The Government did not want to discourage the universities and scientists from embarking on similar projects which would place Britain in the lead in the future, but it must know on what the money was being spent before it was granted. It must also respect a second principle, that if the cost of any project is liable to be greatly increased, the Government department concerned must be kept clearly informed from start to finish and should agree to the extra expenditure before being held liable for it. Mr. Nicholls promised to report to the Lord President what was said in the House.

Transient Reactor Test Facility achieves Criticality

The Transient Reactor Test Facility (*Treat*), a reactor designed to investigate the effect of extreme nuclear heat upon fast reactor fuel elements, achieved criticality at 23.30 E.D.T. on February 23 at the U.S. Atomic Energy Commission's National Reactor Testing Station, Idaho Falls, Idaho. The reactor, designed by the Argonne National Laboratory, can deliver a high-intensity, short-duration surge of nuclear energy without damage to the facility itself. The surge will result when a large number of atoms undergo fission in a short time and will cause intense heat to be generated in the sample being tested. The surge will be useful in simulating abnormal reactor operating conditions and will permit reactor designers to observe on a small scale the effect of such conditions on prototype fuel elements planned for fast reactors. The facility, which resembles a research reactor, is fuelled with uranium oxide uniformly dispersed in graphite. The graphite slows down the neutrons produced by the fission of uranium atoms, enabling the neutrons to collide with other uranium atoms to continue the chain reaction. During the surge, the abnormal amount of heat generated in the fuel due to fission is transferred instantaneously to the graphite, which absorbs the released energy. As the graphite becomes heated, its efficiency in slowing down the neutrons decreases. Consequently fewer

neutrons capable of producing fission are available, permitting the surge to be held to a safe level. For this reason, the reactor is said to have self-limiting operating characteristics.

Research in Tropical Medicine

THE U.S. National Academy of Sciences–National Research Council is to organize a major survey of needs in the field of tropical medicine, under the direction of Dr. W. H. Wright, who recently retired as chief of the Laboratory of Tropical Diseases, National Institutes of Health. The survey will embrace the fields of infectious and parasitic diseases, veterinary medicine, and environmental hygiene. It will include surveys of disease problems in tropical and sub-tropical areas of significant importance to public health and to agricultural and industrial development; of funds expended for medical care and disease control; of financial support for research in medical and hygienic problems of the tropics; of fellowships, teaching programmes, and training facilities; of careers and incentives; of the impact of travel and migrations on tropical disease problems; of the importance of tropical medicine to the economy and man-power situation in the United States. On the basis of these findings it should be possible to assess the need for domestic, foreign and international measures to deal with the problems defined in the survey.

Scientific Linguists in the United States

AN inquiry by the National Science Foundation into the knowledge of foreign languages possessed by American scientists indicates that 97,000 of the 127,000 on the National Register of Scientific and Technical Personnel during 1954–55 (probably more than half of all American scientists) possessed a knowledge of at least one foreign language, German being the commonest, and French coming next. In psychology and the earth sciences, proportionately greater numbers reported knowledge of French, Spanish and other Romance languages, but only about 1 in 50 reported a knowledge of Russian and fewer than 1 in 100 of Chinese.

Science Laboratory Technicians

THE City and Guilds of London Institute and the Institute of Science Technology announce that they have taken important steps to rationalize their examinations and qualifications for science laboratory technicians. Hitherto, both Institutes have held such examinations, but in future there will be only one series, held by the City and Guilds of London Institute on behalf of both Institutes. The conduct of the examinations and their further evolution will be under the guidance of a joint advisory committee of both Institutes and the certificates awarded to successful candidates will bear the heading: "The City and Guilds of London Institute in conjunction with the Institute of Science Technology". Transitional regulations have been agreed to ensure that no student at present preparing for the examinations of the Institute of Science Technology suffers because of the new arrangements. The arrangements for the award of the Fellowship of the Institute of Science Technology remain unchanged.

Soddy's Cubic Equation Machine

FREDERICK SODDY was always looking beyond the borders of his main field of activity, and on several occasions he invaded mathematics. He took a great interest in locating circles within circles, and in calculating the radius of an inside circle he derived a cubic equation, which suggested the possibility of using a geometrical construction for solving the associated cubic equation. He thereupon made a machine with strings and pulleys which, when set with magnitudes derived from a cubic with numerical coefficients, would indicate the corresponding roots if they were all real. After the Second World War he made a machine with pivoted levers and scales which did the same operation without employing strings. In his will he provided for the exploitation of this machine, but this proved impracticable, largely because of the speed with which actual cubic equations can be solved with electronic computers, and his device required some calculations before it could be properly set. His attempt is, however, of some historical interest, and the model has been handed over to the Science Museum.

Applied Mathematics in the Soviet Union

APPRECIATION in the West of the substantial contributions made by Soviet scientists to the study of topics in applied mathematics, such as, for example, the mathematical theory of elasticity, has sometimes been delayed by linguistic difficulties; the summaries available give valuable indications of content, but not always of method. The American Society of Mechanical Engineers has secured a grant from the National Science Foundation which will enable the Pergamon Institute to translate the important periodical, *Prikladnaia Matematika i Mekhanika* (Applied Mathematics and Mechanics), and to publish it as a bi-monthly journal. The aim is to give an exact translation of the original papers, with editorial glosses or comment kept to a minimum. The present series begins with Vol. 22 (No. 1; 1958) of the original, which contains papers accepted during 1956 and 1957, so that translation and re-publication do not seem to have added substantially to the normal time-lag between acceptance and publication. The enterprise should prove of great value to mathematicians in Great Britain and the United States. The annual subscription is 35 dollars or £12 10s., and orders can be placed with the Pergamon Press in London or New York.

Educational Research

FIRST launched some three months ago, this new journal contains information about educational research which should be of interest to practising teachers, local authorities, administrators and other educationists. The articles are particularly valuable because they indicate what may be accepted as established fact, what may reasonably be inferred, and the bearing of the topics referred to upon the day-to-day life of the school and the thought and practice of the teacher. The February issue of the journal (1, No. 2) describes the effects of size of class on teaching, differences between education in town and country, how children understand numbers, and compares the methods of teaching reading. The contributors include well-known educationists, including Sir Cyril Burt and Dr. C. M. Fleming. Future issues are to include articles on the teaching of modern languages; research in technical education; the gifted child; bilingualism; testing attainment; and children's vocabulary. The new journal is issued three times a year in step with school and college

terms. It can be obtained from the publishers, Newnes Educational Publishing Co., Tower House, Southampton Street, Strand, London, W.C.2.

Grants to Students in Britain

A MEMORANDUM submitted by the National Union of Students to the Committee on Grants to Students set up by the Minister of Education and Secretary of State for Scotland under Sir Colin Anderson as chairman has now been published (pp. 28. London: National Union of Students, 1959). Its seventeen recommendations include the financing of awards entirely by the Government and administration by a central grant-awarding authority, or alternatively and as an interim measure, that the awards should be financed mainly by the Ministry of Education, with a proportion to be met from a pool to which all local education authorities should contribute. Awards should be given to those selected by universities for first-degree courses and for comparable courses in other institutions of higher education and the relevant authorities should be invited to review the standard set in 'closed' scholarship examinations. University authorities are urged to consider the practicability of establishing a clearing house system for dealing with university applications, and a review of the values of university scholarships and removal of their maintenance factor are also recommended. In the light of the university review an honorarium for State scholars should be agreed, while the system of supplementation by the Ministry should be ended and the numbers of State scholarships offered should be reviewed each year. Non-recurrent prizes gained in open competition during the course should be tenable without reduction of grant, and awards should also be granted on acceptance to students taking full-time or sandwich courses of degree study at technical colleges or courses recognized by the Ministry of Education as being of comparable status, and these awards should be assessed on the State scale for major awards. It is also recommended that awards should be made without reference to the parental income and that the values of awards should be reviewed every two years instead of every three years.

Graduates in British Industry

THE Information Division of the Department of Scientific and Industrial Research has issued under the title "Graduates in British Industry" (pp. iv+28. London, 1958) a short record of the main findings and applications likely to be of value to firms recruiting graduates, and also to graduates newly appointed to jobs in industry, of the two reports "Graduate Employment—a Sample Survey" and "Graduates in Industry" published by Political and Economic Planning. The record is illustrated with diagrams and the main pointers for management are summarized in the final section. The conclusions from the inquiry are also given concisely following eight short sections dealing with various aspects of the subject.

Atmospheric Temperatures

METEOROLOGISTS, aviators, and those concerned with the planning of air routes, often require information about the winds and temperatures which may be expected in different parts of the globe at various levels. Winds are usually more important, and the Meteorological Office published its Geophysical Memoir No. 85 some time ago to meet this urgent need. Now a companion Memoir, No. 101, has been published, giving temperature information for all parts of the Earth except those regions south of latitude 60° S., mainly at the standard pressure-levels 700, 500, 300, 200, 150 and 100 mb., which range from 10,000 ft. to 56,000 ft. approximately. The presentation involves variation with place, height and time, and is necessarily done graphically, but the nature of the variations is complicated by the variations in the tropopause-level. When any point is sometimes in the troposphere and sometimes in the stratosphere, the temperature variations are normally bimodal, that is to say, the distribution curve shows two peaks, one corresponding to tropospheric and the other to stratospheric events. In this case, special care must be taken in interpreting the data, and it is inevitable that the Memoir contains a great deal of information about the tropopause and its average movements. This, particularly, will interest the meteorologist. The sources of the data have been carefully listed; but a map showing the distribution of the observing points might have been a valuable guide to the extent to which it has been necessary to interpolate over various areas. For example, it has not been possible to include any data since 1952, and sometimes data from adjacent areas are taken for different years. This must sometimes cause apparent changes from place to place due to the different regimes which occur in different years, and there must be very few results from areas between 35° S. and 60° S. The present Memoir is welcome, but even though it has just appeared we shall look forward to a new edition, revised in the light of the very much greater volume of information obtained during the International Geophysical Year.

Assistance from the International Atomic Energy Agency

A PAMPHLET, "Technical Assistance" (pp. 16. Vienna: International Atomic Energy Agency, 1958), outlines the services available from the International Atomic Energy Agency, describing first the kinds of assistance, including fellowships and exchange visits, the provision of advice and information on nuclear energy problems and equipment, and secondly the fields in which member States can request assistance from the Agency. Those listed include library and documentation services; ore prospecting, mining and processing; the design, construction and management of nuclear research laboratories and centres; nuclear research; nuclear reactors; the use of radio-isotopes; safeguards; and problems of health, safety and disposal of waste. Thirdly, rules and practices governing assistance are detailed.

Craters on the Moon

RECENT reports of a volcanic eruption near the lunar crater Alphonsus have apparently stimulated fresh experiments and speculation on the origin of these craters. Apart from the well-known meteoritic and volcanic theories, F. Benario suggested some years ago (*The Strolling Astronomer*, **7**, 19; 1953) that a bursting bubble of gas could produce a crater of similar form. In a recent letter, Dr. A. G. Gaydon and R. C. M. Learner (*Nature*, **183**, 37; 1959) showed photographs of crater-like formations produced by gas effusing through a light dry powder under vacuum. There appears to be some confusion between the two latter experiments, which are in reality quite different. In Benario's work, the sudden bursting of

a gas bubble (in a slurry of plaster of paris, water, and 'Alka-Seltzer') was observed. In Gaydon and Learner's experiments, the crater wall was built up quite slowly by a continuous fountain of falling dust. The latter experiment is more related to volcanic action, but assumes a fall of dust or ash, as at Pompeii, rather than a flow of molten lava. A flow of lava would be expected to build a high mountain, whereas the fall of dust could form a shallow crater of large diameter.

Supplies of Follicle-stimulating Hormone

THE Endocrinology Study Section, U.S. National Institutes of Health, announces that it is prepared to distribute, free of charge to qualified investigators, limited amounts of purified sheep pituitary follicle-stimulating hormone. The preparation has been packaged in two forms: (1) vials containing 5 mgm. for use only as a standard in assay procedures; (2) vials containing 25 mgm., for experimental use. The preparation is a sterile, lyophilized powder, free or nearly free of other hormonal activities. Detailed specifications will be distributed with each sample. Application for supplies should be made to the executive secretary, Dr. R. T. Hill, Endocrinology Study Section, National Institutes of Health, Bethesda 14, Maryland, with a brief outline of the intended work and an estimate of the amount needed. Allocations will be made after consideration of the merits of the intended work.

The Night Sky in April

NEW moon occurs on April 8d. 03h. 29m. U.T. and full moon on April 23d. 05h. 13m. The following conjunctions with the Moon take place: April 11d. 06h., Venus 5° N.; April 14d. 11h., Mars 7° N.; April 25d. 00h., Jupiter 3° S.; April 27d. 14h., Saturn 4° S. In addition to these conjunctions with the Moon, Venus is in conjunction with Aldebaran on April 23d. 14h., Venus being 7·2° N. There will be an annular eclipse of the Sun on April 8, invisible at Greenwich. The path of annularity crosses Australia. Mercury is unfavourably placed for observation. Venus is an evening star, visible in the south-west after sunset. Conditions are very favourable for observation. Venus sets at 21h. 35m., 22h. 20m. and 23h. 00m. on April 1, 15 and 30, respectively; its stellar magnitude is − 3·5. Its distance decreases during the month from 122 to 104 million miles and the visible portion of the visible disk decreases from 0·828 to 0·734. Mars is moving eastwards among the stars and passes from Taurus into Gemini during April. It sets at 1h 25m., 1h. 05m. and 0h. 40m. at the beginning, middle and end of the month, respectively. Its stellar magnitude decreases from + 1·3 to + 1·6, its distance from the Earth increasing from 148 to 173 million miles. Jupiter rises at 23h. 10m., 22h. 10m. and 21h. 00m. on April 1, 15 and 30, respectively; it is near β Scorpii. The stellar magnitude of Jupiter is − 2·0; its distance on April 15 is approximately 420 million miles. Saturn is a morning star in Sagittarius, rising at 2h. 00m., 1h. 05m. and 0h. 00m. at the beginning, middle and end of the month, respectively. Its stellar magnitude is + 0·7; its distance from the Earth on April 15 is approximately 910 million miles. There are no occultations of stars brighter than magnitude 6 observable from Greenwich. The Lyrid meteors are active during April 20–22, but conditions are unfavourable.

Announcements

THE 1958 James Clayton Prize of the Institution of Mechanical Engineers has been awarded jointly to William Munger Heynes (director and chief engineer, Jaguar Cars, Ltd., Coventry) for his outstanding contribution to the design and development of the modern automobile, and to Sir F. Ewart Smith (deputy chairman, Imperial Chemical Industries, Ltd.) for his personal contribution to the advancement of mechanical engineering, particularly in the chemical industry, and to the training of engineers. This prize is awarded annually to a member or members of the Institution who, in the opinion of the Council, contribute most in the year to modern engineering science by research, invention, experimental work or a treatise or paper on a modern engineering subject, or originality in engineering design or by service to engineering.

HARRY POLACHEK, technical director of the Applied Mathematics Laboratory of the David Taylor Model Basin, has recently been appointed chairman of the editorial committee for the quarterly journal *Mathematical Tables and Other Aids to Computation*, published by the Division of Mathematics of the U.S. National Academy of Sciences—National Research Council. He succeeds C. B. Tompkins of the University of California at Los Angeles, who has held the post since November 1954. Articles for publication in the journal should in future be addressed to Harry Polachek, editor, *Mathematical Tables and Other Aids to Computation*, David Taylor Model Basin, Washington 7, D.C.

A SYMPOSIUM on "Oxidation" is to be held in Queen Mary College, London, on April 13 and 14. It is intended to provide an opportunity for discussing the present state of knowledge of the oxidation of organic compounds in the liquid phase and in particular by chromic acid and permanganate. Inquiries can be addressed to Dr. W. J. Hickinbottom, Department of Chemistry, Queen Mary College, London, E.1.

THE tenth Conference of the British Occupational Hygiene Society will be held in Stephenson Hall, University of Sheffield, Oakholme Road, Sheffield, 10, during April 14–15. The Conference, which will be devoted to a discussion of the control of dust and fumes in industry, is to be opened by H.M. Chief Inspector of Factories. Papers will be presented by speakers with experience of the subject in the cotton and asbestos industries, in iron foundries, in welding and electro-plating. Non-members are eligible to attend this conference on payment of a registration fee. Further details can be obtained from the honorary scientific secretary, Dr. D. Turner, The Associated Ethyl Company, Ltd., Ellesmere Port, Cheshire.

THE third meeting of the Welsh Soils Discussion Group will be held on April 19 at the National Agricultural Advisory Service Centre at Trawscoed, near Aberystwyth, when Dr. Rice Williams will open a discussion on "The Soils of the Aberystwyth Area" and arrange for local field inspection of selected soil series. This meeting will occupy most of the day, and arrangements will be made for lunch at Trawscoed. Members of the Group, and others interested, can obtain further information from the secretary of the Group, Mr. J. A. Taylor, Department of Geography, University College of Wales, Aberystwyth.

PROBLEMS OF COLLECTIVE MOTION IN PHYSICS

A CONFERENCE on various aspects of collective behaviour in physics, sponsored by the Physical Society, was held in the Department of Physics in the University of Birmingham during January 2–3; the visitors were received by the vice-chancellor, Dr. R. S. Aitken. It was hoped that the main talks would be suitable as an introduction to the subject for theoretical physicists not familiar with the theory of collective motion and also for experimental physicists. It must be said, however, that apart from the talks on the electron theory of metals and on liquid helium, the talks were clearly addressed to physicists actively working on the subject under discussion: this was even more the case with the discussions.

The first session was devoted to gaseous plasmas. W. B. Thompson (Atomic Energy Research Establishment, Harwell) described a method for deriving the hydromagnetic equations by taking suitably chosen moments of the Boltzmann equation in cases in which collisions may be neglected. This procedure is the counterpart to the Hilbert–Chapman–Enskog method of deriving the equations of ordinary hydrodynamics. S. F. Edwards (Manchester) discussed methods of describing the dynamics of a plasma in thermal equilibrium, including a derivation of the Debye–Hückel screened potential, of the equation of state, and of the plasma oscillation frequency. He also discussed briefly a variational method for deriving the electrical conductivity of a plasma. In the discussion following these two papers it was pointed out that although the equations used by Thompson will break down, thus indicating the possible occurrence of shock-waves, they cannot be used to describe such shock waves as they are essentially an adiabatic approximation. R. Balescu (Brussels) reported briefly on work in Prigogine's group on obtaining by iteration methods asymptotic solutions of the Liouville equation valid for long times and large distances.

The second session dealt with plasma problems in the electron theory of metals. S. Raimes (Imperial College of Science and Technology, London) gave a lucid account of the Bohm–Pines theory of plasma oscillations in metals and of their introduction of a cut-off wave-number k_c above which no collective degrees of freedom will occur. He discussed the shortcomings of Pines's original variational method for determining k_c. Dr. Raimes then showed how this theory can account for the observed density of states curve for such metals as sodium, pointing out the importance, shown by Fletcher and Larson, of second-order effects. In the discussion, Prof. H. Fröhlich (Liverpool) pointed out that k_c should be determined by using a trial wave function in conjunction with the correct Hamiltonian, and not with an approximate Hamiltonian as was done by Pines. S. F. Edwards (Manchester) and R. Leigh (Atomic Energy Research Establishment, Harwell) reported on work in progress along those lines. Edwards is using wave-functions including two-body correlations, whereas Leigh uses wave-functions of the de Shalit–Weisskopf type. In this connexion Fröhlich suggested the consideration of a one-dimensional plasma for investigating the accuracy of the results obtained. D. Bohm (Bristol) discussed the difficulties connected with degrees of freedom with wave-numbers of the order of magnitude of the Debye wave-number. In that connexion, C. G. Kuper (St. Andrews) reported work on a charged boson gas, where a Bogoliubov-type transformation can be used leading to a smooth transition from particle to collective degrees of freedom.

The third session covered liquid helium and superconductivity. The talk by G. V. Chester (Birmingham) was probably for most people one of the most interesting aspects of the conference. In it he discussed the four main kinds of collective motion which occur in liquid helium below 1·6° K. These are the superfluid hydrodynamic potential flow, phonons, rotons and the Onsager–Feynman vortices. Feynman and Cohen's determination of the excitation spectrum was dealt with, and also the experimental work of Hall and Vinen which shows the existence of vortex lines and probably their quantization. In the discussion following this paper, Prof. H. Fröhlich (Liverpool) and Prof. R. E. Peierls (Birmingham) voiced objections to the Feynman–Cohen calculations, while Kuper directed attention to the influence of self-energy corrections. Both O. Penrose (Imperial College of Science and Technology, London) and Kuper asked how far the concept of independent collective excitations was valid. In reply, Chester said that the inelastic neutron scattering data, on helium II, strongly suggest that the concept is valid up to about 1·7° K.

J. G. Valatin (Birmingham) gave an account of the Bardeen–Cooper–Schrieffer theory of superconductivity, mentioning in passing the work of Martin and Schwinger, Gorkov and Galitskii, who are using a Green function approach. He also briefly discussed how the recent theories can account for the electromagnetic properties of superconductors. A lively discussion followed in which Prof. Fröhlich warned against non-gauge invariant theories, because spurious Meissner effects are only too easily obtained. He also pointed out that in the present form of the theory the total momentum fluctuates in the superflow. These fluctuations and those in the number of quasi-particles make it difficult to prove that a superconductor in the present theory has, indeed, zero resistance, as was pointed out by Kuper, who also asked when an energy-gap leads to a superconductor and when to an insulator. Prof. Peierls defined a superconductor as a substance in which a current-carrying state with an energy close to the ground-state level is possible, and in which no transitions are possible from such a state to states with lower current densities, not even through intermediate states, as happens in normal metals. Prof. Peierls also pointed out the difficulty of estimating the errors involved in the present theory and suggested an approach similar to Feynman's approach to liquid helium, since in that case a variational method could be used to estimate the energy gap.

B. Bayman (Copenhagen) discussed the Bohr–Mottelson explanation of the 'energy-gaps' found in nuclei. Empirically, it is found that the first excitations of a single-particle nature—as distinct from a

collective one—in the region of large deformation are much higher in energy than one would predict from the Nilsson model, in which the particles are assumed to move independently in a distorted well. This can be explained by a correlation between pairs of particles of opposite magnetic quantum number, in an unfilled shell. This pairing in angular momentum is similar to the pairing in linear momentum in the Bardeen, Cooper and Schrieffer model. Bayman discussed calculations of Beliaev, who incorporated the pairing simply by making a transformation to a quasi-particle representation. In the region near closed shells, the pairing correlation leads to so-called vibrational states. Their energy spectrum is essentially that produced by Racah's pairing force, so that many of the results of the seniority scheme can be used. In the discussion J. P. Elliott (Southampton) reported on the status of his generalized shell-model approach, and Prof. Peierls discussed briefly the variational scheme for obtaining rotational levels.

The conference was considered by all present to have been a great success, and I for one hope that another conference on the same subject can be arranged in a few years time to review the progress made in the intervening period. D. TER HAAR

INDUSTRIAL HEALTH IN BRITAIN

THE annual report of the Chief Inspector of Factories on Industrial Health for the year 1957* is the first report on industrial health to be published separately and is, to some extent, experimental. Its first chapter, reviewing the year, deals with general questions, including references to new and developing problems and to progress made in solving old problems. The second chapter deals with cases of industrial disease, poisoning and gassing which occurred during the year, and the third chapter deals more extensively with industrial dermatitis. Points which were raised on the statutory draft Compressed Air Special Regulations were all resolved by the end of the year, and the Regulations came into operation on April 21, 1958. The report of the pilot industrial health survey of Halifax was studied in detail by a sub-committee of the Industrial Health Advisory Committee, and afterwards an abridged version of the report was published and arrangements were made for the survey team to approach occupiers of factories in Halifax employing more than 250 workers with the view of interesting them in the advantages of the provision or extension of medical and nursing services.

A committee of inquiry into precautions against anthrax was set up in February 1957, and there was evidence during the year that factory occupiers pay insufficient attention to making adequate provision for first-aid treatment, as required under the Factories Act. In the light of discussions between representatives of Government departments which have responsibilities for first aid, including representatives of the Medical Research Council, the contents of first-aid boxes in factories, as prescribed by the First Aid in Factories Order, 1938, and the leaflet giving advice on first aid treatment have been reviewed, while measures to stimulate recruitment and training of first-aid personnel were also discussed. The third interim report of the Joint Advisory Committee of the Cotton Industry on "Dust in Card Rooms" has been brought to the notice of all firms concerned, and it has been made clear to occupiers that, since a satisfactory system of removing dust in card rooms is now available, it is expected that early action will be taken. Plans were made for extending the Inspectorate's facilities for collecting and analysing dust by formation of a second dust-counting team.

The chapter on industrial dermatitis summarizes known facts on the cause and particularly the prevention of this disease which have already been made known in departmental and other publications. Predisposing factors are also indicated, and stress is laid on the importance of taking appropriate measures before and not after trouble has occurred. These include replacement of the harmful agent by one that is non-irritant or less harmful; selection of personnel; reduction of contact to a minimum, or complete elimination of contact; regular and frequent inspection by trained observers; and cleansing of the skin.

* Ministry of Labour and National Service. Annual Report of the Chief Inspector of Factories on Industrial Health for the year 1957. Pp. 50. (Cmnd. 558.) (London: H.M. Stationery Office, 1958.) 3s. net.

INTERNATIONAL STANDARDS FOR DRINKING-WATER

THERE is at present a wide diversity in water treatment and quality in different countries, and the need for some sort of international agreement on what constitutes a safe supply of drinking-water has long been apparent. The question was raised at the Congress of the International Water Supply Association in Amsterdam in 1949 and again in Paris in 1952, but the prospect of accord in the near future seemed remote. In 1953 the matter was taken up by the World Health Organization, and a questionnaire was circulated to member States. The replies served to reiterate the differences in attitude, and in view of the increase in international travel, particularly by air, to emphasize the desirability of agreed standards.

Regional study groups of experts were convened to study the problem in the European, Eastern Mediterranean, and South-east Asia and Western Pacific regions. The reports of these various groups were used as a basis for discussion by a further group meeting in Geneva in 1956 and the standards now proposed were put forward by this body. It is not suggested that these standards represent perfection; on the contrary, as the preface specifically points out, they are tentative and subject to modification after experience of their application. In some cases the standard proposed is not as high as that habitually achieved by some undertakings, but the sources of water supply used for public consumption are so

different in their chemical and bacteriological content and treatment methods so limited by technical and financial resources that it is not to be expected that the high standard reached in certain localities will immediately become universally applicable. The standards suggested represent rather the minimum requirements to which a public water supply should conform and in the absence of which it cannot be considered entirely free from risk. This is in itself a great advance and will be of inestimable value to health and water authorities in those parts of the world where at present water supplies do not attain the desired criteria.

In the International Standards for Drinking Water*, recently published by the World Health Organization, a chapter is devoted to each of the subjects of bacteriological, chemical and physical, biological and radiological requirements. This is followed by a section in which are indicated matters requiring further research in each of these fields. In some cases it might appear that the subject suggested for study has already been adequately investigated, but it can do no harm for some old ground to be re-covered if the results are made more widely known and a re-assessment of some cherished beliefs may prove salutary.

In a rapidly expanding subject it is inevitable that a publication of this kind should be somewhat behind the latest information. This applies particularly to the chapter on radiological requirements, which seems unduly brief. There is no mention of the part played by the naturally occurring isotope, potassium-40, in contributing towards the total radioactivity in water, although it is only fair to say that for further information the reader is referred to the recommendations of the International Commission on Radiological Protection.

Any consideration of standards, particularly in the bacteriological or chemical spheres, must take some account of the methods whereby these are measured, and the second, and larger, portion of the book is devoted to a series of approved methods for bacteriological, chemical and biological examination of water. Starting with a list of required materials, each procedure is explained step by step in simple language which is a model of clarity. Not the least important sections are those detailing the particulars to be supplied with samples and the recommendations on the frequency of sampling. Tables are given for the computation of the most probable number index with upper and lower confidence levels. In the chemical section, lists with permissible levels are provided not only of those naturally occurring substances which may affect potability but also of toxic materials such as lead, arsenic, selenium, chromium and cyanide, with details of methods for their estimation.

If one may venture a further minor criticism of so valuable a work, it is that a comprehensive index might have increased its usefulness. As it is, the volume is an excellent example of what can be achieved by international co-operation and a milestone on the way to safe water supplies throughout the world.

E. Windle Taylor

* World Health Organization. International Standards for Drinking Water. Pp. 152. (Geneva: World Health Organization; London: H.M. Stationery Office, 1958.) 12 Swiss francs; 20s.; 4 dollars.

THE WEIZMANN INSTITUTE OF SCIENCE

THE report for 1956–57 of the Weizmann Institute of Science*, besides summarizing the scientific activities of the several departments and sections, includes a list of publications during the period and details of the scientific staff, as well as of the administrative and technical staff and supporting committees. It is introduced by a statement of policy for the future of the Institute by Mr. M. W. Weisgal, chairman of the Executive Council, which expresses grave concern regarding the financial position of the Institute. Anticipated income for the four years April 1956–March 1960 fell short of estimated requirements by about 6 million dollars, and the measures proposed by Mr. Weisgal include launching a campaign for an Endowment Fund of 25 million dollars.

Fundamental research in the Department of Applied Mathematics was directed mainly to the solution of mathematical problems in statistical mechanics, wave propagation, geophysics, hydrodynamics and X-ray crystallography. In nuclear physics, besides investigation on nuclear models, some work on reactor physics was undertaken for the Israel Atomic Energy Commission. The Department of Isotope Research records progress in the production of stable isotopes, the use of stable and radioactive isotopes in studying the mechanism of inorganic and organic reactions and in various applications of natural and artificial radioactivity. Investigations by the Department of Organic Chemistry embraced the structure of natural compounds, the chemistry of the sphingolipids, steroid and acetylene chemistry, syntheses in the terpene series, petroleum chemistry and applied spectroscopy.

Besides studies of polyelectrolytes, including their biological aspects, in the Department of Polymer Research, gels, membranes and mechano-chemistry received attention, as well as polynitroethylene, polyvinyl bromide and polyvinylanthracene. The Department of X-ray Crystallography continued to investigate intra- and inter-molecular compression forces on molecular structure and to study the mechanism of solid-state reactions by combined X-ray crystallographic and physico-chemical methods, while work in the Department of Experimental Biology included such diverse fields as the biological mechanism of the induction of tumours, the metabolism of urethane in relation to its tumour-inducing activity, the mechanism of deciduoma formation and its relation to placental implantation of the ovum, immuno-genetics of tumour implantation, radiobiological aspects of tumour immunity, biochemical and endocrinological aspects of sugar metabolism and problems in human genetics and neuropharmacology. The Department of Biophysics continued to be concerned mainly with work on synthetic poly-α-amino-acids and their use in elucidating chemical and physical properties of proteins and natural

* Weizmann Institute of Science. Report 1956–1957. Pp. 190. (Rehovoth: Weizmann Institute of Science, 1958.)

polypeptides. In the Department of Electronics a more generalized theory of rotational magnetic processes was formulated and several magnetic measuring devices were built. The main effort of the Infra-red Section was on the construction of a large vacuum spectrometer-refractometer for use in the near infra-red region; the Section of Photochemistry and Spectroscopy investigated chemical processes involved in photochromic phenomena and the influence of ionizing radiation and high-energy particles on phototropic and photochromic compounds; and the Section of Plant Genetics was concerned with the mechanism of the development of sex in plants.

THE BRITISH FLORA DURING 1958

THE publication during 1958 of a new and authoritative list of vascular plants accepted as established members of the British flora[1], and including some 2,895 species and 538 hybrids, is a timely reminder of the relative thoroughness with which the flora has been investigated. The additions which continue to be made annually are evidence that native plants can be long overlooked even on the best-worked ground, and that new aliens continue to find ecological niches where they can establish themselves in competition with species already present. Comparison of the new list with the last full-scale list of the British flora issued in 1928 shows that since then there has been a net addition of some 370 established species. That botanists can add an average of 12 such species annually (and this takes no account of casuals) shows how rapidly the known British flora is changing.

At the annual exhibition meeting of the Botanical Society of the British Isles, held in the lecture hall of the Royal Horticultural Society on November 29, the exhibits included several interesting additions to the British list. One of these was *Juncus subulatus* from the salt-marsh at Berrow, Somerset, which was shown by E. W. Davies and J. Willis (Bristol). This salt-marsh was formed about 1910, and its development has been under observation since 1921 and has been the subject of several ecological studies[2–5]. Two large and flourishing colonies of the rush are spreading vegetatively by vigorous growth of the rhizomes in the zone of *Scirpus maritimus*—the latter appeared about 1926 and increased extremely rapidly during the next two years[3]. *Juncus subulatus* is widespread in the salt-marshes of the Mediterranean coast, and Berrow is apparently its most northerly station. Here it is reproducing from seed as well as vegetatively. Now that attention has been directed to the plant, it may well be found elsewhere on the coast of Britain—it can easily be passed over as *J. maritimus* or perhaps as a luxuriant *J. gerardi*.

Another rush added to the British list was shown by N. D. Simpson and S. M. Walters (Cambridge). This is *J. bufonius* subsp. *foliosus*, also a native of the Mediterranean countries, which was found in two places in west Cork and one in south Kerry. In the field it is strikingly different from the usual *J. bufonius*, having flowers often more than 1 cm. in diameter with a dark stripe bordering the greenish midrib of the perianth segments and wider leaves which are not setaceous. The seeds also differ, but the Irish material was not sufficiently ripe to check this character.

An undescribed *Sorbus* from the Avon Gorge was shown by E. F. Warburg (Oxford). This has previously been confused with *S. hungarica*. Dr. Warburg also exhibited two forms of *Sorbus pseudofennica* from Arran which are probably distinct apomictic clones. Two well-established aliens were exhibited by H. J. M. Bowen (Harwell). *Geranium pilosum*, a native of New Zealand, was found in Alderney, and *Hydrocotyle moschata*, also from New Zealand, is freely naturalized in Valencia Island, Kerry.

Several very rare plants were found in new localities during the year. One of the most interesting of these is *Lythrum hyssopifolia*, which was found in quantity at Whittlesford, Cambridgeshire, by Mrs. G. Crompton, and which was the subject of an exhibit by D. E. Coombe, F. H. Perring and S. M. Walters (Cambridge). This is at present known to occur regularly only in Jersey, and it has been found in only four other localities in the present century; but revision of the records shows that there has also been some confusion with an allied species sometimes found as a casual. *Lythrum hyssopifolia* is native in central and eastern England, growing in wet open communities. It seems likely that seed may remain viable for long periods and enable the plant to re-appear in favourable seasons. Evidently the persistent wet conditions of 1958 suited it well.

The discovery of another new locality for an orchid, *Spiranthes romanzoffiana*, is also of special interest. This was found by Lough Corrib in Galway by a party collecting records for the Society's Maps Scheme, and a photograph was exhibited by Miss A. K. Harding and Mrs. B. H. S. Russell. The new locality represents a considerable extension of range from those previously recorded in the south and north of Ireland—it seems that this orchid is spreading into new and widely scattered habitats (including western Scotland and Devonshire). The first authentic inland record of *Equisetum variegatum* from the south of England was the subject of an exhibit by E. F. Warburg (Oxford). This horsetail was found by E. G. Arthurs in an old quarry at Cothill, Berkshire; the nearest previously known station is at Weston-super-Mare.

An important new hybrid was shown by P. M. Benoit. This was between *Euphorbia paralias* and *E. portlandica*, with morphological characters convincingly intermediate between the two parents and fruits failing to complete their development. He found it in two places on the coast of Merionethshire. P. M. Benoit also exhibited an interesting series of synthesized hybrids of *Stellaria*. These included *S. media* × *neglecta* (90 per cent), *S. pallida* × *neglecta* (50 per cent), *S. neglecta* × *pallida* (50 per cent) and *S. pallida* × *media* (23 per cent). The percentages indicate the approximate proportions of sterile pollen grains. The following back-crosses were also shown: *S.* (*pallida* × *neglecta*) × *neglecta*, *S. pallida* × (*pallida* × *neglecta*), *S.* (*pallida* × *media*) × *media*. J. A. Ratter (Liverpool) exhibited hybrids of *Spergularia*, and J. P. Savidge (Liverpool) showed specimens of the only naturally occurring hybrid population of *Callitriche* found during his investigation of the genus. This was from Hillerød, Denmark; the pollen

was completely abortive, no female flowers could be found, and the likely parentage was *C. platycarpa* × *C. polymorpha* (the hybrid is a triploid with 15 chromosomes).

Several exhibits demonstrated new work using modern techniques on critical groups. C. D. K. Cook (Cambridge) showed specimens of *Ranunculus tripartitus* from the Lizard and *R. lutarius* from the New Forest, and clones which he had grown from these. These clones are virtually impossible to distinguish in summer; but differences can be detected when they are in their winter state. All attempts at inducing capillary leaves in plants which lacked them have proved unsuccessful. M. C. F. Proctor (Exeter) exhibited a careful study of the characters and habitat variations of *Ulex minor* and *U. gallii*, with maps showing their distribution in Britain and abroad. The two species have been much confused, but appear to be distinct. E. W. Davies (Bristol) is working on *Asparagus*. *A. officinalis* subsp. *officinalis*, the cultivated form, is diploid, while the wild plant from the Lizard, subsp. *prostratus*, is tetraploid ($2n = 40$). A study of the latter on the Lizard peninsula showed that at three localities female plants were at least three times as abundant as male and were morphologically distinct. B. T. Styles (Oxford) demonstrated progress made in work on the species problem in *Polygonum* Section *Avicularia*. Trampling and the situation of the habitat have a considerable influence on the different forms the plants take, but those to which the names *P. aequale* ($2n = 40$), *P. aviculare* s.str. ($2n = 60$) and *P. rurivagum* ($2n = 60$) are at present applied appear to be morphologically distinct. Other exhibits concerned with variation included: pink-flowered *Calystegia*, R. K. Brummitt (Liverpool); *Juncus articulatus*, J. R. Cullen (Liverpool); *Mentha* × *dumetorum*, R. M. Harley (Oxford); *Valeriana officinalis*, C. L. A. Leakey (Cambridge); and *Melampyrum pratense*, A. J. E. Smith. T. D. V. Swinscow showed a living plant which was a descendant, through an unknown number of generations, of the variety of *Dryopteris dilatata* described by T. Moore in 1859 as var. *lepidota*. The plant is a tetraploid ($n = 82$) as is usual with the species in Britain, but morphologically it is perfectly distinct. Moore regarded it as of native origin, but evidence of this is obscure.

Much of the effort of British botanists in the field during 1958 was devoted to collecting records for the Distribution Maps Scheme. This was the final season for data to be incorporated in the atlas, and a map was exhibited to show the distribution by squares of the records received. This showed that there are now no major gaps—in the whole of the British Isles only about thirty of the approximately 3,500 10-kilometre squares of the extended National Grid remain unvisited; ten of these are in Ireland and the remainder mainly in the Outer Hebrides and outlying islands of the Orkneys. In England the average number of records per square is about 400, in Wales 300, in Scotland nearly 200, and in Ireland about 150. The total number of records should exceed 1¼ million. A specimen volume with sample maps and overlays was exhibited to indicate the form the published atlas will take. This may not be available for another two years, but in the meanwhile work will continue on special problems, for which members will be invited to contribute data.

An exhibit of some interesting plants from the British herbarium of the British Museum (Natural History) included a series of *Bromus* with several species not well understood by workers in Britain. From the herbarium of the Royal Botanic Gardens, Kew, there were specimens of species believed to be now extinct in Britain. This exhibit was prepared by the late R. A. Graham, who also showed four 'legendary' British orchids (*Serapias neglecta*, *Calypso bulbosa*, *Limnodorum abortivum* and *Orchis pallens*) with a review of the records and evidence. E. S. Edees and K. M. Goodway (Keele) directed attention to salt-marsh plants growing in Staffordshire. These were first brought to notice by Robert Plot in 1686, and at least ten species still occur. Salt deep in the Keuper Marl is brought to the surface by springs, and at least seven areas with salt-marsh plants have been found during the present century. Since these populations are more than fifty miles from the coast, and are likely to have been isolated from the coastal populations for several thousand years, they deserve experimental investigation. F. Rose and Miss P. A. Hitch (Bedford College) demonstrated work in progress on the distribution of *Chrysosplenium oppositifolium* and *C. alternifolium* in south-east England, and experimental work with the object of endeavouring to determine what chemical factors, if any, may be responsible.

Exhibits concerned with alien plants were more numerous than usual as these were particularly invited. Wool aliens were shown by Miss C. M. Goodman, J. G. Dony and J. E. Lousley, while Mrs. H. N. Clokie (Oxford) exhibited specimens from the Druce herbarium of interest in connexion with the published work[6] of Miss I. M. Hayward and G. C. Druce on this group of aliens. Miss R. M. Barnes (Norwich Castle Museum) showed specimens and photographs from a Suffolk tannery where sheep skins imported from many countries are processed. Other exhibitors provided aliens of garden origin, or brought in with grain, or of special habitats like refuse heaps—some of the species shown are now well established, and others likely to become so. An example of this was *Erinus alpinus*, which D. P. Young found associated with a native arctic–alpine flora near Bettyhill, Caithness.

There were several displays of excellent colour-slides, including a fine series shown by the National Trust for Scotland of arctic–alpine plants on Ben Lawers. Postage stamps with pictures of plants of interest to botanists were shown by Mrs. A. N. Gibby. The exhibit illustrating the junior meeting at Banyuls in the Pyrenees at Easter 1958 was a reminder of the work the Society undertakes for students.

From the Society's 1958 exhibition it would appear that progress in adding to the knowledge of the British flora was less spectacular than it has been recently. Important additions were less than the average of the past thirty years, and exhibits based on sound research work less numerous. Variations in the interest of exhibits must inevitably arise from year to year, and the fact that 1958 was not a good one is not necessarily an indication that there has been any decline in the activity of British botanists. In view of the great handicap to serious field work imposed by inclement weather throughout the season it is surprising that they have achieved so much.

J. E. Lousley

[1] Dandy, J. E., "List of British Vascular Plants" (London, 1958).
[2] Thompson, H. S., *J. Ecol.*, **10**, 53 (1922).
[3] Thompson, H. S., *Proc. Bristol Nat. Soc.*, (4), **7**, 35 (1928).
[4] Thompson, H. S., *J. Ecol.*, **18**, 126 (1930).
[5] Boley, G. M., *Proc. Bristol Nat. Soc.*, (4), **9**, 427 (1942).
[6] Hayward, I. M., and Druce, G. C., "The Adventive Flora of Tweedside" (Arbroath, 1919).

LINEAR TRANSFER OF A POTENTIALLY MUTANT STATE IN BACTERIA

By Dr. F. KAUDEWITZ
Max-Planck-Institut für Virusforschung, Tübingen

BY observing the pattern of expression shown by reversions from auxotrophy to prototrophy, induced by ultra-violet light, a new type of mutation delay in bacteria has been found. The strain used was the lysin-deficient lys-1 of *Salmonella typhimurium* isolated by E. Witkin. Until about 50 hr. after induction by ultra-violet irradiation the reversions of lys-1 to prototrophy are extremely sensitive to temperature: incubation below 34° C. gives optimal yields, above 36·5° C. reversions were not found (Fig. 1).

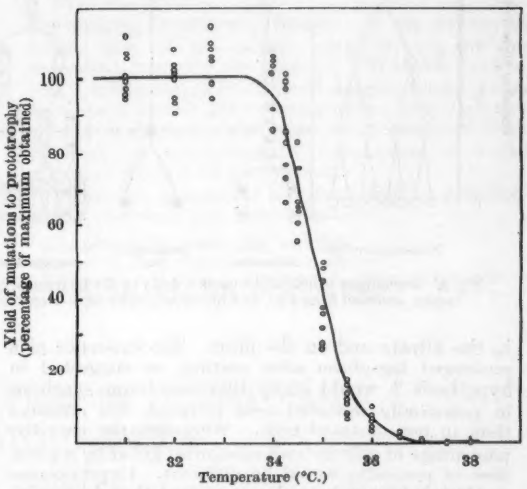


Fig. 1. Yield of mutations induced by ultra-violet light irradiation to prototrophy of strain lys-1 of *Salmonella typhimurium* as a function of incubation temperature

The growth-curve of lys-1 cells irradiated with ultra-violet light so as to yield a survival-rate of 10 per cent and plated on minimal-agar enriched with 0·05 per cent nutrient broth (Fig. 2, curve *a*) shows that cell division begins after a lag-period of about 3 hr. After incubation at 34° C. for 4 days, prototrophic colonies appear each of which represents an independent mutation. Newcombe's technique of re-spreading at intervals after plating[1] provides a method for estimating the number of cells potentially capable of reverting afterwards to stable prototrophs. Fig. 2, curve *b* demonstrates that the increase in such cells starts 5 hr. 40 min. after plating, that is, 2 hr. 40 min. later than the increase of non-mutated cells. From 5 hr. 40 min. to about 7 hr. the curve of increase of these potential reversions (Fig. 2*b*) and the growth-curve of lys-1 cells not induced to prototrophy (Fig. 2*a*) have the same slope.

At about 7 hr., however, there is a sudden break in the curve of increase. Thereafter, this curve is concave even though the results are plotted on a semi-logarithmic scale. The deviation from linearity can be explained by the fact that the reverted clones are *inhomogeneous with respect to their growth-characteristics*. Re-spreading favours selection of fast-growing types. Thus the later re-spreading is carried out the higher will be the percentage of fast-growing colonies obtained (scheme Fig. 2*c*). Hence, at about 7 hr. the slope of the curve of increase mainly results from the multiplication of slow-growing clones; at about 25 hr. the slope depends almost entirely upon the multiplication of fast-growing colonies.

The delay in the increase of mutated cells observed after irradiation might be caused by: (1) the temporary formation of filaments which afterwards break up (Fig. 3); (2) a prolonged lag-phase in the mutated cells; (3) the segregation of genetic units, for example, separation of a mutated nucleus from unchanged ones; (4) the linear transfer of the character 'mutated' or 'potentially mutated' to one of two daughter-cells.

The first-mentioned possibility was disproved by the results of experiments in which cell-suspensions obtained by washing plates 5 hr. 10 min. after plating were centrifuged and filtered. No difference was found between the percentage of potential mutants present in the pellet and in the supernatant or present

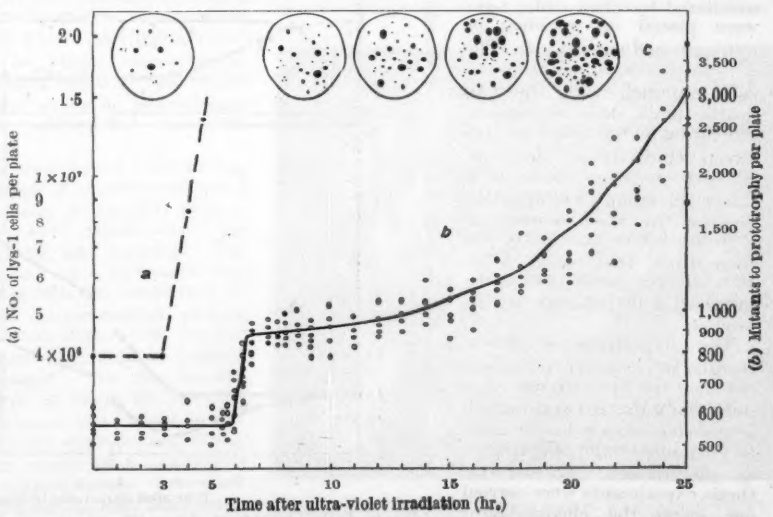


Fig. 2. Relation of potential mutation to prototrophy to time of re-spreading after induction by ultra-violet light. *a*, Growth curve of surviving cells: *b*, number of cells/plate capable of giving rise to prototrophic colonies; *c*, scheme of appearance of plates

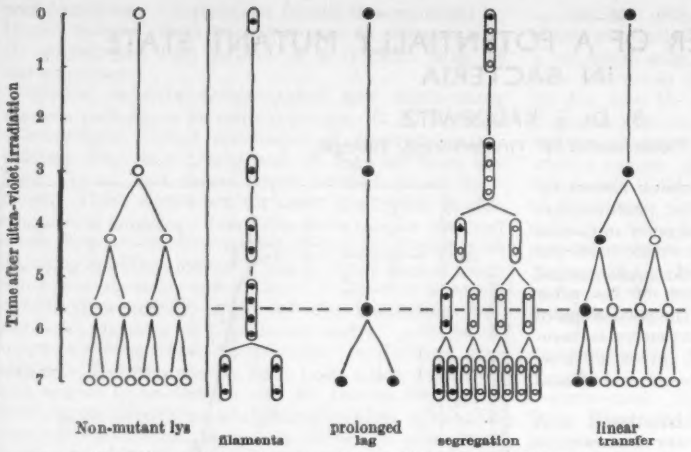


Fig. 3. Mechanisms which might cause a delay in the increase of cells mutated to prototrophy observed from 3 hr. to 5 hr. 40 min. after ultra-violet induction (cf. Fig. 2)

in the filtrate and on the filter. The existence of a prolonged lag-phase after plating, as suggested in hypothesis 2, would imply that membrane synthesis in potentially mutated cells is much less effective than in non-mutated cells. Were this the case the percentage of cells in both categories killed by a given dose of penicillin would be different. Experimental results[3], however, have demonstrated that during the time-interval 3–5 hr. the same percentage of potentially mutated and non-mutated cells were killed by a comparable dose of penicillin. This finding indicates *that potentially mutated cells do not have a prolonged* lag-phase. The third hypothesis, namely, a segregation of genetic units, would require a minimal number of cell divisions for the expression of the recessive phenotype of a mutant. Therefore, a prolongation of generation-time would result in a postponement in the increase of mutated cells. To test this hypothesis aliquots of cells irradiated by ultra-violet light were placed on enriched or minimal medium (Fig. 4). The growth-curves of non-mutated cells obtained with the two media have different slopes, indicating a different time between cell-divisions. However, on both media, as shown with the re-spreading technique, the increase in the number of mutants starts at exactly the same time, that is, at 5 hr. 40 min. after plating. Thus the segregation hypothesis is disproved.

The hypothesis of linear transfer of character 'reversion' assumes the concurrence of a potentially mutant state which is transferred in a linear order to only one of the offspring of an affected cell. To test this thesis experiments were carried out using the chequerboard technique of Witkin and Thomas[3]. This method yielded clonal offspring of the irradiated cells. Assuming linear transfer it would be expected that at any time before 5 hr. 40 min. each clone derived from a potentially mutated cell would contain only one mutated cell, but many non-mutated cells. At 7 hr. and later, however, there should be in such a clone at least two cells which give rise to prototrophic colonies. This actually was found (Fig. 5). The delay of the increase in number of potentially mutated lys-1 cells after irradiation by ultra-violet light was proved by this finding to be due to linear transfer of the potentiality to express the prototrophic character.

To solve the problem of what kind of material transfers this potentiality, experiments still in progress add the following evidence: while about 10 per cent of reversion strains can serve as donors in transduction of lys-1 to prototrophy, 100 per cent of reversion strains (after infection) give rise to phages which transduce all wild-type markers of strain lys-1. By transduction analysis the transducible reversions were shown to be due to suppressors at loci other than the mutational site of lys-1. In early stages of their origin all lys-1 reversions, transducible or not, show the same degree of temperature sensitivity and linear transferability. From this *it may be concluded that all lys-1 reversions have the* same basic mechanism of origin. Why, then, are some of them transducible, and others not? The results of experiments in which X-irradiation was applied to transducing phages synthesized in different

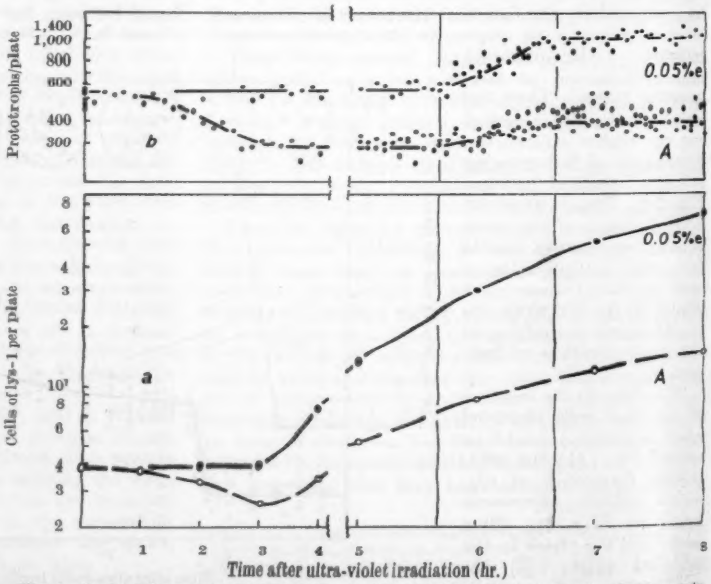


Fig. 4. Lack of dependence of time of increase in potential mutants of prototrophy upon rate of growth of cells surviving after ultra-violet light irradiation. *a*, Growth curves of surviving cells on minimal agar (*A*) and minimal agar enriched with 0·05 per cent broth; *b*, number of cells/plate capable of giving rise to prototrophic colonies on either medium

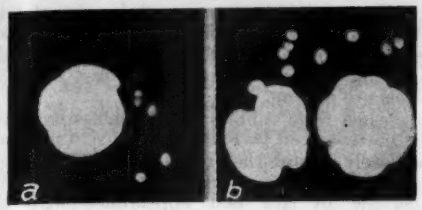


Fig. 5. Results of clonal re-spreading (using the chequer-board technique of Witkin and Thomas) of lys-1 cells potentially mutated to prototrophy. *a*, Re-spreading at 5 hr. 20 min. after ultra-violet induction: the clone was composed of 5 non-mutated microcolony-forming cells and only one cell capable of giving rise to a macrocolony; *b*, re-spreading at 7 hr. after ultra-violet induction: the clone was composed of 9 non-mutated microcolony-forming cells but two cells capable of giving rise to macrocolonies

strains of transducible reversions indicate target sizes which were often larger than one gene-locus. This observation led to the conclusion that the suppressors are non-intragenic changes. They represent translocations of chromosomal segments which in most strains of reversions are too big in size to be incorporated into phage.

The same temperature sensitivity and linear transferability and the rare occurrence of transducibility were shown by reversions arising spontaneously of lys-1 and by reversions of 17 of 134 auxotrophic mutants of *Salmonella typhimurium* and *E. coli*. Thus the phenomena are not unique to strain lys-1.

From the experimental results presented the following working hypothesis is formed. By the mutational event, part of the genetic material may become separated from the chromosome. Without duplication it is transferred by each cell-division for some time in a linear order. Its re-incorporation may lead to a variety of changes in chromosomal architecture which function as non-intragenic suppressors to cause different degrees of prototrophy.

A detailed account of this work will be published in the *Zeitschrift für Vererbungslehre*.

[1] Newcombe, H. B., *Nature*, **164**, 150 (1949).
[2] Kaudewitz, F., *Z. Naturforschg.*, **10**, *b*, 562 (1955).
[3] Witkin, E., and Thomas, Constance T., Carnegie Institution of Washington Year Book, No. 54, 234 (1955).

LIQUID CRYSTALS OF LIPID IN NORMAL AND ATHEROMATOUS TISSUE

By G. T. STEWART

Medical Research Council Laboratories, Carshalton, Surrey

THE chemical composition of the extractable lipids in atherosclerotic lesions is well known, but much less is known about the physico-chemical forms in which the lipids gain access to, and exist in, these lesions in the body. Poole and Florey[1] have shown how sudanophilic fat first appears in the aortic intimal deposits of atheroma in the cholesterol-fed rabbit, and have demonstrated the presence of lipoid-laden macrophages on the endothelial surface. Their observations do not support the idea advanced by Rannie and Duguid[2] that lipid is incorporated into the atheromatous lesion when endothelium overgrows adherent clumps of these macrophages. Sudanophilic fat can be demonstrated in endothelial cytoplasm in areas of intima where no macroscopic deposition of atheroma is visible and where no macrophages are present.

One difficulty which constantly limits work in this field is the fact that microscopy is usually performed upon tissues which have been physically altered, especially with regard to lipid distribution, by fixation, freezing or embedding, and staining. The Oxford workers (Florey *et al.*) have overcome this difficulty so far as circulating cells are concerned by inserting ear-chambers into cholesterol-fed rabbits and have thereby demonstrated that, under experimental conditions, birefringent lipid may be present intracellularly in macrophages[3]. In the studies described below, an attempt is made to examine atherosclerotic and normal tissues and plasma in the fresh state, and at temperatures approaching 37° C. to compare the lipids seen under such conditions with those viewed in conventionally processed tissues. It is thought that the results may have some bearing on the problem of the integration of certain forms of lipid in tissue.

Microscopic Identification of Lipid in Fresh Tissue

When frozen sections of unfixed atheromatous vessels from humans or from cholesterol-fed rabbits are examined by conventional techniques, various forms of lipid besides sudanophilic fat can be detected microscopically including, in unstained frozen sections or films, crystals of fatty acid, free cholesterol and amorphous birefringent material (Fig. 1). A few spheroid objects of diam. 0·5–5μ with a cross or other interference pattern on polarization ('spherulites')

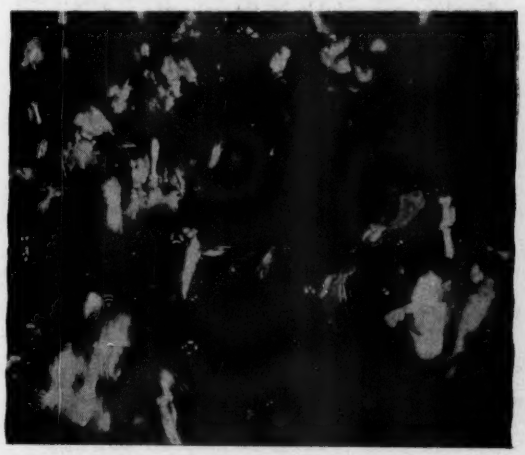


Fig. 1. Film made after freezing from an atheromatous deposit in a cholesterol-fed rabbit. Crystals of fatty acid and free cholesterol, amorphous material and a few spherulites are present (× 400, polarized light)

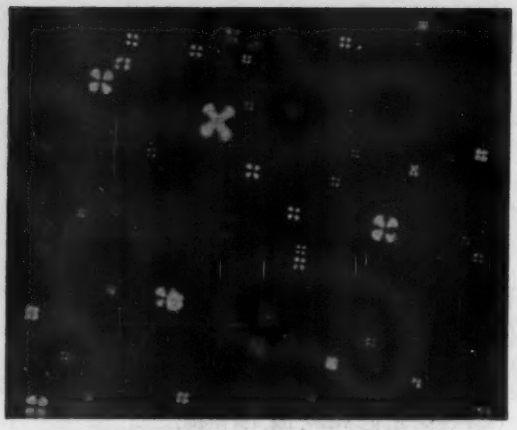


Fig. 2. Film made at 37° C. and photographed at room temperature from an atheromatous deposit in a cholesterol-fed rabbit. The birefringent material consists almost entirely of spherulites (× 400, polarized light)

may also be seen but are never numerous and may be absent in sections viewed soon after freezing.

A very different picture is obtained when fresh preparations are made at 24–37° C. in distilled water or other inert medium from the warm aortic lesions of a cholesterol-fed rabbit which has just been killed. Under such conditions, the intimal deposits are in a semi-liquid state and show, in microscopic films, a predominance of spherulites of diam. 0·5–2·0μ, especially in the superficial layers (Fig. 2). These spherulites, though varying slightly in size, are uniform in shape and interference figure when viewed immediately under polarized white or monochromatic light. Some minute birefringent, ovoid or amorphous particles may also be present; but the true crystals of free cholesterol and fatty acids seen in frozen sections are not visible. On cooling to room temperature, these crystals begin to form slowly, though the spherulites persist. Rapid cooling to 4° C. causes disintegration of many of the spherulites. At −10° to −20° C., this disintegration is practically instantaneous and complete. The spherulites are soluble in fat solvents and show no sudanophilia, though amorphous sudanophilic material is present in films of fresh, warm tissue as in frozen sections. The addition of digitonin (0·5 per cent in 50 per cent alcohol) causes gradual disappearance of the spherulites, with replacement by amorphous and crystalline precipitates.

Spherulites similar to the above are present also in some normal tissues, intra- and extra-cellularly, when scrapings or imprint preparations are made from fresh, wet tissue. They are conspicuous in myelin from the white matter of brain and spinal cord, and may be prominent in the adrenal cortex as well as in the ovaries and secretory endometrium of women of child-bearing age. Spherulites may also be found in testis and semen. In myelin, the optical interference figure of the spherulites may not be greatly altered by freezing or formol-fixation, though in other tissues, spherulites may disappear on freezing and reappear gradually at 24–37° C. Spherulites are not present in normal adipose tissue.

Identification of Lipid Particles in Plasma

Particulate lipid in plasma is usually seen in the form of chylomicrons under dark-ground illumination. These particles, composed largely of triglyceride, are mainly isotropic in plasma examined in the state of normal alimentary lipæmia. In healthy human and rabbit plasma, few, if any, anisotropic particles are present.

In plasma from rabbits fed on cholesterol, anisotropic particles can be found regularly in films made immediately from the meniscus after low-speed centrifugation. These particles comprise spherulites, comparable in size and appearance with those observed in tissue, and minute ovoid or stellate objects, of chylomicron-size, but strongly birefringent. Both types of particle are present extracellularly.

Intravenous injection of sulphated polysaccharides (for example, heparin 100–500 units/kgm.) under conditions already described[4] causes a temporary aggregation of particulate lipid in plasmas, sampled 3–30 min. after injection. Low-speed centrifugation of plasma in this state, carried out at 37° C., causes an opaque pellicle loaded with spherulites and amorphous (isotropic) lipid to separate at the meniscus (Fig. 3). Ultracentrifugation of this plasma at room temperature, adjusted according to the technique of de Lalla and Gofman[5] to a mean density of 1·063 gm./ml. at a mean centrifugal force of 79,420g,

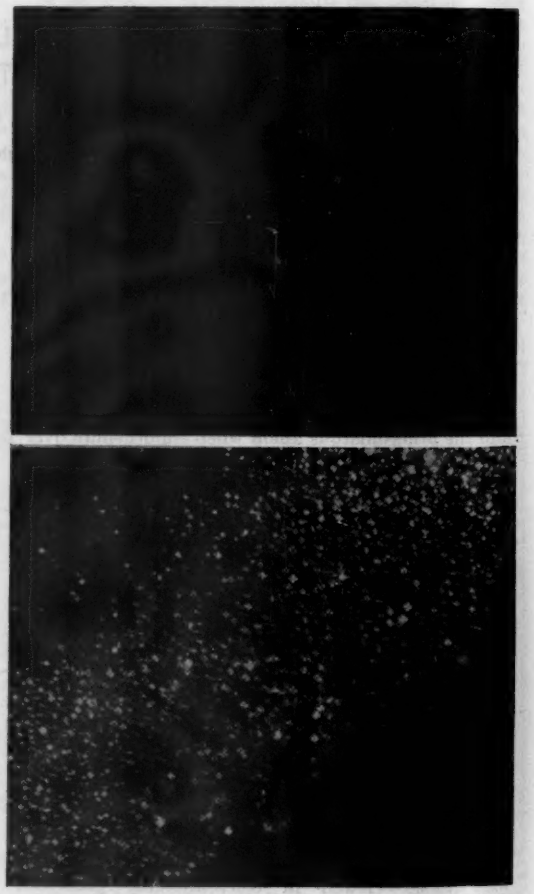


Fig. 3. Films from meniscus of hypercholesterolæmic rabbit plasma after low-speed centrifugation. Above, before injection: a few spherulites are present; below, after heparin 100 units/kgm. intravenously. A pellicle of identically orientated spherulites is present (× 100, polarized light)

causes the spherulites to separate in the low-density layer, in association with lipoproteins of hydrated density 1·00–1·04 gm./ml. This separation occurs within 5 hr. in the ultracentrifuge and serves to indicate the density of spherulites of average size, but does not effect a concentration comparable to low-speed centrifugation at 24–37° C. after the injection of heparin.

Similar spherulites and ovoid particles can sometimes be found, cell-free, in abnormally lipæmic human plasma by the same technique. None has so far been found in normal plasmas of children and adults; but small numbers (of the order of 3–6 in a cover-slip film) have been found in the low-density layer of ultracentrifuged plasmas from three adult males with essential hyperlipæmia and two children with nephrotic hyperlipæmia.

Properties of Spherulites in Tissue and Plasma

In preparations kept at 24–37° C., the spherulites show crystal-like growth, partly as discrete globules, partly as confluent masses. Cooling prevents this growth and provokes true crystallization of fatty acids and steroid rhombs. At 37° C. in glycerol, the larger globules show complex radial and concentric interference figures and a display of polarization colours in convergent white light. The interference figure is altered in accordance with the sign of birefringence when a quarter-wave plate is inserted into the optical system.

When films of plasma or tissue are examined immediately at 37° C., without cooling, the spherulites show a more fluid consistency. The globules are elongated or wavy in outline, and may be larger and confluent (Fig. 4). The interference figure is still discernible, though deformed, within the globule, but no polarization colours are seen. Extinction of the polarized beams leaves the globule with greenish droplet-like refractility in white light.

Possible Significance of these Observations

It is obvious that the spherulites and some of the accompanying ovoid particles here described belong to the liquid phase of tissue, and show crystalline properties while still in a state of 'flow' in plasma and cells at or slightly below body temperature. Such particles possess, therefore, the essential properties of 'liquid crystals', a term first used by Lehmann in 1889 [6] to describe the intermediate paracrystalline form of some pure organic substances. Such crystals, now well recognized in various physical systems[7,8], especially where esters, soaps and cholesteric substances are present[9], have received little attention in biology.

Fig. 4. Film from meniscus of hypercholesterolæmic rabbit plasma after intravenous injection of heparin 100 units/kgm. Whole experiment, including photograph, performed at 37° C. The spherulites are in a state of flow with wavy outlines (× 400, polarized light)

The liquid crystalline form can occur when there are aggregates of systematically orientated molecules of birefringent substance[10]. At a certain temperature, the solid goes into a turbid phase, which is both birefringent and fluid. In this mesomorphic state, the molecules are maintained in stable orientation by specific polar groups and unspecific van der Waals attractions[11]. Alterations in temperature and other physical stresses disrupt the relatively weak intramolecular forces of cohesion, with loss of birefringence, specific interference figures and fluidity.

The liquid crystals here identified in plasma and tissue are stable at, or slightly below, body temperature. Some of their properties—the type of true crystallization on cooling, the development of iridescent polarization colours and complex interference figures on growth—are consistent with the presence of cholesterol esters together with other non-sudanophilic lipids in their structure. It is likely that some of the birefringent material observed in adrenal cortex by Yoffey and Baxter[12] and in circulating macrophages by French[3] is of a similar type. When viewed in fresh tissue, all the birefringent particles are of chylomicron size, or slightly larger, and these presumably represent the natural nuclei from which further paracrystalline growth proceeds in older preparations.

In the plasma colloid, the spherulites and ovoid particles appear to be associated mainly with the macromolecular lipoproteins of lowest density. In some normal tissues—though not to any significant extent in adipose tissue—closely related if not identical particles are present physiologically, while, under pathological conditions, similar particles form a major component of atheromatous substances in the liquid state. The occurrence of the liquid crystalline form indicates that such particles, unlike other forms of physiological and pathological lipid, possess internal cohesive forces which confer stability and may influence their distribution and retention in tissue. The high concentration of spherulites found in the intima of atherosclerotic vessels, together with their association with the low-density lipoproteins of abnormally lipæmic plasmas, suggest that lipid in this form plays a part in initiating and maintaining the atheromatous deposit.

[1] Poole, J. C. F., and Florey, H. W., *J. Path. Bact.*, **75**, 245 (1958).
[2] Rannie, I., and Duguid, J. B., *J. Path. Bact.*, **66**, 395 (1953).
[3] French, J. E., in "Lectures on General Pathology", ed. H. W. Florey, 2nd edit (London, 1958).
[4] Stewart, G. T., *Brit. J. Exp. Path.*, **39**, 109 (1958).
[5] de Lalla, O. F., and Gofman, J. W., in "Methods of Biochemical Analysis", **1** (ed. Glick) (New York, 1954).
[6] Lehmann, O., *Z. phys. Chem.*, **4**, 468 (1889).
[7] Tutton, A. E. H., "The Natural History of Crystals" (London, 1924).
[8] Vorlander, D., in "Liquid Crystals and Anisotropic Melts" (Discussion held by Faraday Society, April 1933).
[9] Bernal, J. D., and Crowfoot, D., in "Liquid Crystals and Anisotropic Melts" (Discussion held by Faraday Society, April 1933).
[10] Chamot, E. M., and Mason, C. W., "Handbook of Chemical Microscopy" (New York and London, 1958).
[11] Hartshorne, N. H., and Stuart, A., "Crystals and the Polarising Microscope" (London, 1952).
[12] Yoffey, J. M., and Baxter, J. S., *J. Anat.*, **81**, 335 (1947).

TRICHLORACETIC ACID-INSOLUBLE PHOSPHATE COMPOUNDS IN CARTILAGE

By R. G. WHITEHEAD and Dr. S. M. WEIDMANN

Biological Research Unit, Dental School and Hospital, University of Leeds

In a previous communication, we[1] gave the analysis of phosphate compounds in the fraction of cartilage soluble in trichloracetic acid, and found that both adenosine triphosphate and orthophosphate had a high specific activity of incorporated phosphorus-32 when the latter was injected intraperitoneally. The acid-insoluble phosphate compounds have not hitherto been studied in detail.

Dallemagne[2] showed that as a young animal grows older the calcium/phosphorus ratio of ashed cartilage rises until the ratio of tricalcium phosphate is reached. Refuting the theory that the low calcium/phosphorus ratio was due to the primary precipitation of dicalcium phosphate, it was suggested that the phosphate present in excess of that required for a calcium/phosphorus ratio of 1·94 was attached to the organic element afterwards to be hydrolysed when the requisite calcium ions were available for deposition of tricalcium phosphate. In the light of this theory, it was of interest to investigate the matrix-bound phosphate compounds of cartilage.

In preliminary work it was shown that although an upward gradation with age of calcium/phosphorus ratios occurred in the ashed epiphyseal cartilage samples, in the fraction soluble in trichloracetic acid the ratio was always 1·9–2·1, indicating that a compound of the tricalcium phosphate type was always deposited even in the earliest phases of calcification. The phosphate compounds remaining in the acid-insoluble fraction were further analysed by the method described by Heald[3] for similar compounds in brain.

The phospholipid was extracted with chloroform–methanol 2 : 1 (v/v) at 0° C., and the nucleic acids using urea dissolved in a saturated solution of sodium chloride and ammonium sulphate at 100° C. The nucleic acids were afterwards precipitated from this extract as their copper salts. The residue remaining after the extraction of phospholipid and nucleic acid was incubated in 1·0 *N* potassium hydroxide for 18 hr. at 37° C., then 0·2 vol. of 6·0 *N* hydrochloric acid and 0·5 vol. of 10 per cent (w/v) trichloracetic acid were added. The resultant small precipitate together with the remainder of the undissolved organic material were removed by centrifugation. The supernatant was examined for organic and inorganic phosphate by the method of Berenblum and Chain[4]. The inorganic phosphate is produced by the alkaline hydrolysis of phosphoprotein and is of significant importance in brain metabolism. The organically bound phosphate of this fraction is of unknown structure.

The composition of the acid-insoluble phosphate compounds obtained from five litter-mate puppies (3 weeks old) are given in Table 1. It will be observed that no phosphoprotein was detected (in which respect cartilage differs from brain). The concentration of nucleic acid phosphate, the 'unknown organic phosphate' fraction and the acid-insoluble residual phosphate are quite similar to those found by Heald[3] in brain. There is also present a considerable proportion of phospholipid.

Table 1. Distribution of Phosphorus Compounds in the Trichloracetic Acid-insoluble Fraction of Epiphyseal Cartilage
The results represent the mean values ± *S.E.M.*

Fraction	No. of animals	Concentration (mgm. P/100 gm. wet wt.)
Phospholipid	5	10·5 ± 0·3
Nucleic acid	5	6·6 ± 0·9
Phosphoprotein	5	None
'Unknown organic phosphate'	5	6·9 ± 0·9
Residue	5	1·53 ± 0·03

In some experiments 330 μc./kgm. of phosphorus-32 was injected intraperitoneally into young kittens and the animals killed 2 hr. later. In Table 2 the specific activity of incorporated phosphorus-32 in the phospholipid, nucleic acid and 'unknown organic phosphate' fraction is compared with the values for adenosine triphosphate. In relation to the adenosine triphosphate the turn-over of these trichloracetic acid-insoluble compounds is very low (Table 2).

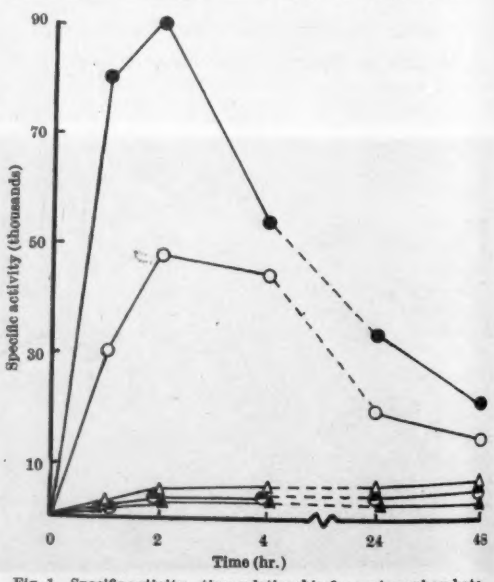


Fig. 1. Specific activity – time relationship for various phosphate compounds in ossifying cartilage, taken from litter-mate puppies, aged 21 days. For definition of specific activity see Whitehead and Weidmann (ref. 6)
●, Orthophosphate; ○, adenosine triphosphate; △, phospholipid; ◒, nucleic acid; ▲, 'unknown organic phosphate' fraction

Table 2. SPECIFIC ACTIVITY OF VARIOUS PHOSPHATE COMPOUNDS IN EPIPHYSEAL CARTILAGE FROM 3-WEEK-OLD KITTENS, MEASURED 2 HR. AFTER THE INJECTION OF PHOSPHORUS-32

Results represent mean values ± *S.E.M.* For definition of specific activity, see Whitehead and Weidmann (ref. 6)

Phosphate compound	No. of animals	Specific activity
Adenosine triphosphate	45	24,800 ± 940
Phospholipid	6	1,000 ± 60
Nucleic acid	6	2,480 ± 280
'Unknown organic phosphate' fraction	6	2,370 ± 160

The results presented strongly suggest the idea that the 'excess' phosphate was temporarily bound to the matrix prior to its deposition as bone salt to be incorrect. It seems probable these phosphate compounds are only part of the normal cell constituents. If part of this phosphate were concerned in a cyclic transfer system from acid-soluble phosphate esters, a close relationship between the magnitude of turn-overs in the two types of compound would be expected; but this is not the case. The latter point was confirmed by a study of the time relationship for the incorporation of phosphorus-32 into the various phosphate compounds. The results (Fig. 1) show the three acid-insoluble compounds exhibit only a slow incorporation of isotope similar to that observed in other tissues, while the adenosine triphosphate has a marked peak at 2–4 hr., and even after 48 hr. has a considerably higher specific activity than the insoluble compounds.

Cartier and Picard[5] suggested that adenosine triphosphate stimulated calcification in cartilage by forming a primary seed, after which bone salt crystallized out automatically on to the seed, and recent work by us[6] has produced evidence in support of this idea. If the seeding effect of adenosine triphosphate is achieved by the phosphorylation of the matrix, as Cartier and Picard[5] have suggested, then the seed should be highly labelled. It would appear that owing to the absence of any highly active component in the acid-insoluble fraction, these compounds do not participate in the seeding mechanism, which one would expect to be a rapid reaction. The considerable loss of tracer after 2–4 hr. in the cartilage orthophosphate of bone salt (Fig. 1) indicates that a fast resorption and redeposition of new bone salt is occurring. It is unlikely that such a rapid reaction could be stimulated by a slowly synthesized phosphate compound.

DiStephano, Neuman and Rouser[7] characterized an acid-insoluble phosphate compound in cartilage which they suggested may play a part in the calcification mechanism. Presumably this compound would be contained in the 'unknown organic phosphate' fraction; but again the absence of any appreciable activity in this fraction indicates the doubtful importance of this ester in calcification.

It would appear that if adenosine triphosphate is essential in the epitactic stimulation of calcification, then this must be achieved either by the formation of a labile acid-soluble seed or as a result of its high energy content. The acid-insoluble phosphate compounds appear to be of little significance in the rapid endochondral calcification of cartilage.

This work has been supported by a grant from the Medical Research Council.

1 Whitehead, R. G., and Weidmann, S. M., *Nature*, **180**, 1196 (1957).
2 Dallemagne, M. J., *Nature*, **161**, 115 (1948).
3 Heald, P. J., *Biochem. J.*, **66**, 659 (1957).
4 Berenblum, I., and Chain, E., *Biochem. J.*, **32**, 295 (1938).
5 Cartier, P., and Picard, J., *Bull. Soc. Chim. Biol.*, Paris, **37**, 1196 (1955).
6 Whitehead, R. G., and Weidmann, S. M., *Biochem. J.*, **71**, 312 (1959).
7 DiStephano, V., Neuman, W. F., and Rouser, G., *Arch. Biochem.*, **47**, 218 (1953).

PREALBUMIN AS A COMPLEX IN THE α-GLOBULIN FRACTION IN HUMAN SERUM

By DR. J. R. TATA*

National Institute for Medical Research, Mill Hill, London, N.W.7

THE thyroid hormone is normally transported in the blood in association with the 'thyroxine-binding protein', the principal characteristic of which is an electrophoretic mobility on filter paper or in the moving boundary system intermediate between those of α_1- and α_2-globulins[1,2]. This protein fraction can also be concentrated in the fractions of human serum rich in α-globulin submitted to ethanol precipitation or passage through ion-exchange resins[3]. However, experiments with a recently devised non-electrophoretic method for comparing the thyroxine-binding affinities of different proteins[4] showed human serum prealbumin (as isolated by Schultze *et al.*[5]) to have a more intense interaction with thyroxine than other serum proteins. In this connexion it has been shown lately that thyroxine, added to normal human serum, migrated with the prealbumin fraction in starch gel electrophoresis[6], and that a part of the added thyroxine could be made to migrate with the prealbumin fraction even in paper electrophoresis if a fraction rich in prealbumin were added to whole serum[7]. These results have been interpreted by Ingbar[7] to mean that thyroxine-binding protein and prealbumin are two distinct proteins which bind thyroxine, each possessing a high affinity for thyroxine; these are in addition to human serum albumin, which is a secondary binding protein, effective in serum only at higher concentrations of thyroxine. However, the results outlined below indicate that the thyroxine-binding properties of the α-globulin fraction of thyroxine-binding protein are principally due to prealbumin, present as a complex of unknown composition. In this respect, except for the binding of hæmoglobin by haptoglobins[8], little is known about physiologically significant protein–protein interaction in normal serum[9].

As a first approach, the high tryptophan content of human serum prealbumin[5] was used for detecting it in small amounts on paper by development with Ehrlich's[10] *p*-dimethylaminobenzaldehyde reagent. Prealbumin and the Cohn fractions IV-4 and IV-6

* Beit Memorial Fellow.

rich in α-globulin were the only serum protein fractions to give a positive tryptophan reaction on spot tests on paper (10–25 μgm.), whereas all the other fractions, including α-globulin (Lister), β-globulin (fraction G-2, Lister), β_1-globulin (Protein Foundation, Inc.) and human serum albumin (Lister), failed to react or only reacted very feebly with Ehrlich's reagent. The results of zone electrophoresis on paper (using conventional horizontal electrophoresis at *p*H 8·6 [11] and analysis of thyroxine-binding[2]) are shown in Figs. 1 and 2.

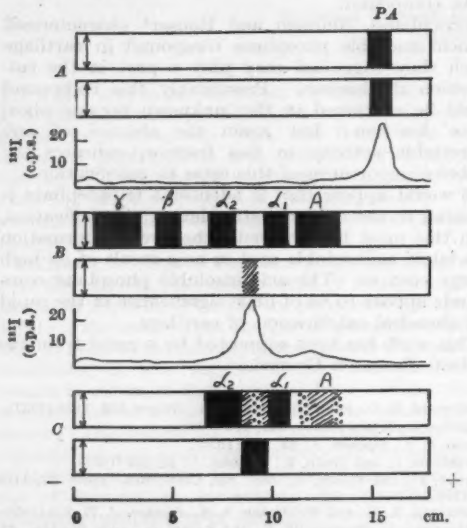


Fig. 1. Paper electrophoretic analysis of (*A*) human serum prealbumin (2·5 mgm./ml.), (*B*) whole human serum, and (*C*) Cohn fraction IV-4 (12·5 mgm./ml.). The upper strip indicates the positions of proteins when stained with bromphenol blue and the lower strip that of the tryptophan-rich protein fraction when stained with *p*-dimethylaminobenzaldehyde for the same sample. Full black areas indicate a strong reaction, hatched lines a moderate one and dotted zones a feeble but positive staining reaction. The curves represent the distribution of radioactivity in electrophoretic pattern if a trace amount of L-thyroxine labelled with iodine-131 was added before electrophoresis. Electrophoresis was performed in 0·075 *M* veronal buffer, *p*H 8·6 at 3·6 V/cm. for 18 hr. Double-headed arrows denote the point of application of samples. [*A*, albumin; *PA*, prealbumin]

Prealbumin when analysed alone was shown to be a fast-moving protein, using both bromophenol blue and Ehrlich's reagent (Fig. 1*A*), but in electrophoretic patterns of whole serum (Fig. 1*B*) or Cohn fraction IV-4 (Fig. 1*C*) the tryptophan-rich fraction was found in the position occupied by thyroxine-binding protein, namely, between the α_1- and α_2-globulins.

The first indication that human serum prealbumin could form a complex in serum was obtained in experiments in which increasing amounts of prealbumin were added to serum (Fig. 2).

When an amount of prealbumin equal to that used alone (2·5 mgm./ml., Fig. 1*A*) was added to whole human serum (Fig. 2*A*) only a small proportion of it was recovered on electrophoresis as 'free' prealbumin; at the same time, an increase in the material rich in tryptophan in the α-globulin zone was found. Doubling the amount of prealbumin added to the serum (Fig. 2*B*) led to an increased recovery of the original fast-moving component with no concomitant increase in the amount of material rich in tryptophan in the α_1–α_2-globulin zone, suggesting saturation of a possible complex. A qualitatively similar result was obtained when Cohn fraction IV-4 was used instead

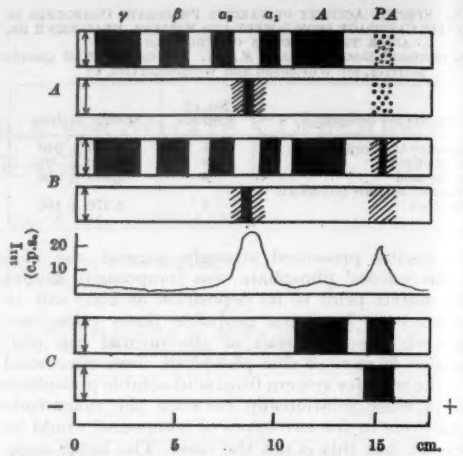


Fig. 2. Paper electrophoretic analysis of human serum to which prealbumin was added to the extent of (*A*) 2·5 mgm./ml., and (*B*) 5·0 mgm./ml. The sample *C* consisted of a mixture of human serum albumin (50 mgm./ml. and prealbumin (5 mgm./ml.). Other details as in Fig. 1

of whole serum, which further suggested that prealbumin might be associated with an α-globulin component. No such complex formation could be detected with other serum fractions, including human serum albumin (Fig. 2*C*).

As regards thyroxine-binding, it is noteworthy that when thyroxine labelled with iodine-131 was added to these proteins in trace amounts, it was recovered in the tryptophan-rich zone (Figs. 1 and 2). If more than one zone rich in tryptophan were present (Fig. 2*B*), thyroxine was distributed between the zones in direct proportion to the intensity of the Ehrlich tryptophan reaction. It should be noted that similar distribution of radioactivity was obtained by Ingbar[7] in the paper electrophoretic analysis of thyroxine-binding by serum supplemented with a prealbumin-rich fraction.

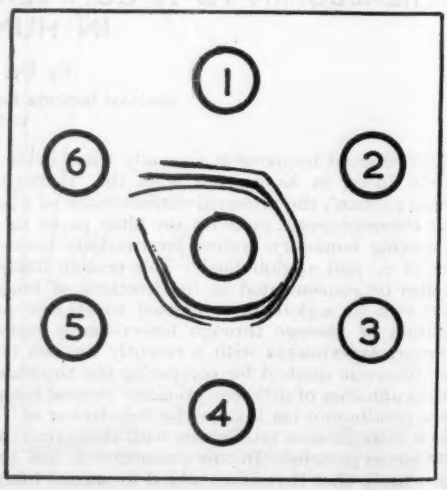


Fig. 3. Interaction between rabbit antiserum against human serum prealbumin (central well) and (1) prealbumin, (2) thyroxine-binding protein eluate from electrophoretic separation of whole serum, (3) Cohn fraction IV-4, (4) ten-fold concentrate of human amniotic liquor, (5) whole human serum, and (6) human serum albumin, according to Ouchterlony's (ref. 12) technique of diffusion in agar gel

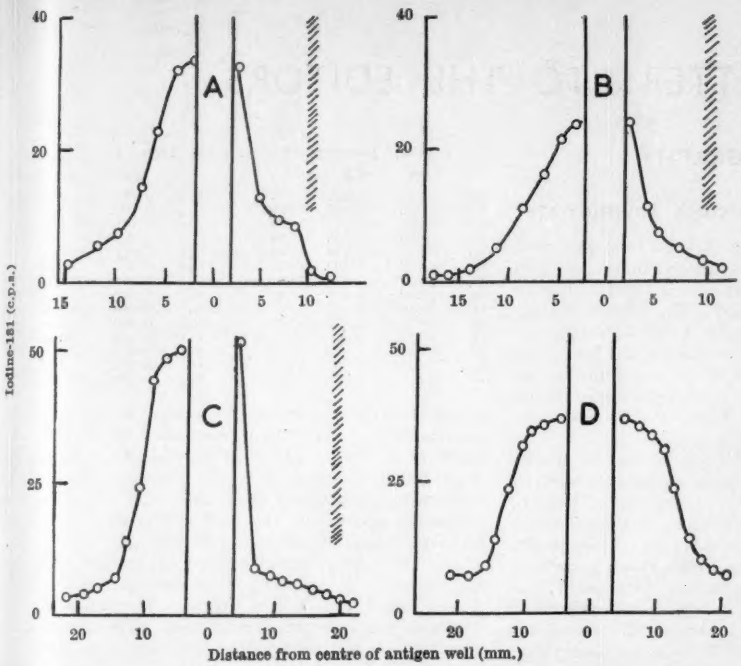


Fig. 4. Distribution of radioactivity in agar gel by a method of profile counting after the immunological reaction has occurred. Thyroxine labelled with iodine-131 was added to all samples tested against rabbit anti-prealbumin antiserum. (*A*) prealbumin (1·0 mgm./ml.); (*B*) whole serum (four-fold dilution); (*C*) thyroxine-binding protein eluate corresponding to 1 ml. of serum; (*D*) human serum albumin (20 mgm./ml.). The hatched bars indicate the position of the precipitate formed after 48 hr. The position of the well containing rabbit anti-human prealbumin antiserum was to the right of the antigen well in the diagram

The second approach to the problem was an immunological one. By using Ouchterlony's[12] technique of diffusion in agar gel (Fig. 3), the following protein fractions reacted with rabbit antiserum against human serum prealbumin to give one or more of the three precipitation lines (depending on the antigen concentration) observed with prealbumin: (*a*) whole human serum; (*b*) Cohn fraction IV-4; (*c*) eluate of thyroxine-binding protein in the α-globulin fraction obtained from whole serum by electrophoresis on a cellulose column[13] (after marking it with a trace of thyroxine labelled with iodine-131); (*d*) a ten-fold concentrate of human amniotic liquor, which also possesses a tryptophan-rich component intermediate between the α_1- and α_2-globulins in paper electrophoresis that exhibits intense thyroxine binding[14]. Human serum albumin (Lister) at various concentrations did not show any reaction with the anti-prealbumin serum under similar conditions.

Finally, strong evidence that one at least of the prealbumins present in thyroxine-binding protein is responsible for the binding of thyroxine was obtained from profile counting of the radioactivity[15] in agar gels after marking the test samples with a trace of thyroxine labelled with iodine-131 (0·03–0·08 μgm./ml.).

In the absence of a reaction with antibody, the distribution of radioactivity on either side of the antigen well is symmetrical, whereas if precipitation occurs the antigen does not diffuse freely on the side of the antibody, so that the profile counts show asymmetry.

As Fig. 4 shows, the pronounced asymmetry found in the distribution of radioactivity after reaction with anti-prealbumin serum indicates that most of the thyroxine in whole serum, in Cohn fraction IV-4 and in eluate of thyroxine-binding protein from whole serum was bound to the prealbumin component. The absence of any accumulation of radioactivity in the zone of the antigen–antibody precipitate can be explained by supposing that the reaction between prealbumin and anti-prealbumin results in the liberation of thyroxine originally bound to prealbumin. Evidence that this does, in fact, occur will be presented elsewhere. The symmetrical distribution of radioactivity and the absence of a precipitation line with albumin (Fig. 4*D*) further demonstrates the lack of prealbumin in this fraction and indicates that albumin binds thyroxine independently of prealbumin.

It is concluded from these experiments that a large part of human serum prealbumin is present as a complex in the α-globulin fraction and that it is responsible for the binding of thyroxine observed in thyroxine-binding protein. Other questions have arisen from this work, such as the identity of the component associated with prealbumin and whether the thyroxine-binding of the complex is greater than that of its individual components. Attempts to resolve these problems and full experimental details will be described elsewhere.

I am indebted to Dr. A. C. Allison for valuable advice and help throughout this investigation. I also wish to thank Prof. H. E. Schultze for generous supplies of human serum prealbumin and immune rabbit serum, Dr. D. R. Bangham for human amniotic liquor and Dr. S. H. Ingbar for Cohn fraction IV-4.

[1] Gordon, A. H., Gross, J., O'Connor, D., and Pitt-Rivers, R., *Nature*, **169**, 19 (1952).
[2] Robbins, J., and Rall, J. E., "Rec. Adv. Hormone Res.", **13**, 161 (1957).
[3] Freinkel, N., Dowling, J. T., and Ingbar, S. H., *J. Clin. Invest.*, **34**, 1698 (1955). Ingbar, S. H., Dowling, J. T., and Freinkel, N., *Endocrinol.*, **61**, 321 (1958).
[4] Tata, J. R., *Biochem. J.* (in the press).
[5] Schultze, H. E., Schönenberger, M., and Schwick, G., *Biochem. Z.*, **328**, 267 (1956).
[6] Rich, C., and Bearn, A. G., *Endocrinol.*, **62**, 687 (1958).
[7] Ingbar, S. H., *Endocrinol.*, **63**, 256 (1958).
[8] Jayle, M. F., *Bull. Soc. Chim. Biol.*, Paris, **21**, 14 (1939). Jayle, M. F., and Boussier, G., *Expos. Ann. Biochim. Med.*, **17**, 157 (1955). Smithies, O., and Walker, N. F., *Nature*, **176**, 1265 (1955). Allison, A. C., and ApRees, W., *Brit. Med. J.*, **ii**, 1137 (1957). Allison, A. C., *Proc. Roy. Soc. Med.*, **51**, 641 (1958).
[9] Waugh, D. F., "Adv. Protein Chem.", **9**, 375 (1954).
[10] Smith, I., *Nature*, **171**, 43 (1953).
[11] Block, R. J., Durrum, E. L., and Zweig, G., "A Manual of Paper Chromatography and Electrophoresis" (Academic Press, Inc., New York, 1955).
[12] Ouchterlony, O., *Acta Path. Microbiol. Scand.*, **25**, 186 (1948). Grabar, P., *Ann. N.Y. Acad. Sci.*, **69**, 591 (1957).
[13] Flodin, P., and Porath, J., *Biochim. Biophys. Acta*, **23**, 91 (1954).
[14] Bangham, D. R. (unpublished results).
[15] Allison, A. C., and Humphrey, J. H. (unpublished results).

LETTERS TO THE EDITORS

CRYSTALLOGRAPHY

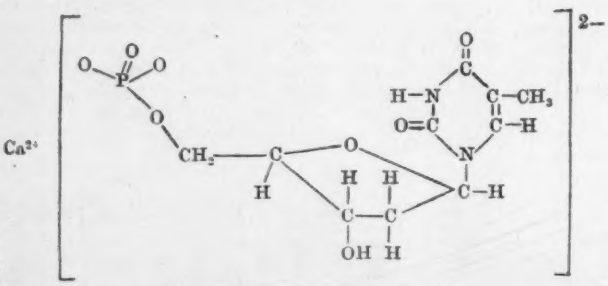
Crystal Structure of Calcium Thymidylate

Numerous recent observations, both biological and chemical, have indicated that deoxyribonucleic acid is very probably the substrate which serves to store and transport genetic information. The initial formulation of this hypothesis brought forth a variety of structural speculations aimed at linking the biological role of deoxyribonucleic acid to its molecular structure. The most interesting and successful model was proposed by Crick and Watson[1]; it has since been supported by many other studies.

However, the success of this model should not be allowed to obscure certain limitations inherent in the stereochemical assumptions of Crick and Watson. They assumed that the elementary units of which deoxyribonucleic acid is composed have essentially the same structure in the entire molecule as in crystals of individual degradation products. At present, the structures of about a dozen purine and pyrimidine bases are known[2–11], and in addition, the structures of two ribosides, cytidine[12] and 5′-bromo-5′-deoxythymidine[13], and one ribotide, adenylic acid[14], have been determined. Spencer[15] has recently emphasized the need for precise structural information about the components of deoxyribonucleic acid.

It thus appeared to us worth while to determine the crystal structure of a deoxyribotide, which is in effect one of the 'monomers' of deoxyribonucleic acid, so that direct evidence might be obtained of the mutual arrangement of the three fundamental groups: the phosphate, the sugar, and the base.

The calcium salt of thymidylic acid, which has the following structural formula, proved suitable for X-ray crystallographic analysis:



The salt was supplied to us by the California Foundation for Biochemical Research, and was recrystallized by careful evaporation of an aqueous solution. The crystal used for the X-ray work had approximate dimensions 1·5 mm. × 0·5 mm. × 0·2 mm.

X-ray photographs were taken with both Weissenberg and precession cameras and copper $K\alpha$ radiation. The dimensions of the monoclinic unit cell are: $a = 14{\cdot}40 \pm 0{\cdot}02$ A., $b = 6{\cdot}87 \pm 0{\cdot}01$ A., $c = 9{\cdot}81 \pm 0{\cdot}01$ A., and $\beta = 90° 58' \pm 3'$. The only systematic extinctions, $0k0$ with k odd, lead uniquely to the space-group $P2_1$ for this optically active molecule. The density of the crystal, measured by flotation in a mixture of 'Freon 113' and bromoform, lies between 1·58 and 1·61 gm./cm.³; the density calculated on the assumption that the unit cell contains two molecules of calcium thymidylate, each accompanied by 6 molecules of water, is 1·60 gm./cm.³.

Table 1. Approximate Fractional Atomic Co-ordinates

	x/a	y/b	z/c		x/a	y/b	z/c
Ca	0·041	0·500	0·926	O_{13}	0·154	0·500	0·106
P	0·090	0·002	0·810	O_{14}	0·200	0·740	0·340
O_1	0·062	−0·173	0·870	N_1	0·461	0·165	0·677
O_2	0·055	0·139	0·894	N_3	0·522	0·165	0·460
O_3	0·078	−0·033	0·668	C_1	0·251	−0·001	0·959
O_4	0·193	0·002	0·826	C_2	0·337	0·036	0·969
O_5	0·413	−0·034	0·860	C_3	0·342	0·258	0·951
O_6	0·328	0·335	1·077	C_4	0·445	0·296	0·905
O_7	0·616	0·161	0·657	C_5	0·468	0·163	0·826
O_8	0·441	0·171	0·268	C_6	0·530	0·161	0·605
O_9	0·133	0·500	0·712	C_7	0·436	0·165	0·405
O_{10}	0·314	0·666	0·687	C_8	0·362	0·169	0·477
O_{11}	0·059	0·301	0·524	C_9	0·265	0·173	0·404
O_{12}	0·087	0·003	0·223	C_{10}	0·371	0·160	0·606

Intensity photographs were taken by the equi-inclination Weissenberg method for the layers $k = 0$ to 5 and $l = 0$ to 8. The multiple film method was used and corrections were made in the usual way, although no absorption correction was applied. All diffraction maxima for which $s = \frac{2\sin\theta}{\lambda}$ is less than 1·17 A.$^{-1}$ were measured; of the total of 1,788 reflexions, 214 were too weak to be observed.

The structure determination was first begun in Strasbourg with no other means of calculation than Beevers–Lipson strips. The Patterson projection on (010), together with certain general features of the diffraction photographs, gave the location of the calcium atom and the phosphate group, and permitted the approximate determination of the position and orientation of the sugar and the base. However, despite many attempts, uncertainties concerning individual atomic positions and especially the ignorance of the locations of the water molecules prevented our finding a trial structure sufficiently good to serve as the starting point for the usual convergence to a refined structure.

The structure was then resolved unambiguously from a sharpened three-dimensional Patterson function calculated on *Swac*[16]. By quantitative interpretation of this function we were able to determine the position of every atom of the molecule of calcium thymidylate and of several of the water molecules, although certain ambiguities remained with the latter at this stage. One round each of three-dimensional Fourier synthesis and of least squares have served to improve the atomic position and remove the ambiguities about the number and the positions of water molecules. Refinement of the structure is still in progress, but the atomic co-ordinates are now known with a precision which we estimate to be, on the average, better than 0·05 A. in x and z, and better than 0·1 A. in y. The approximate atomic co-ordinates are given in Table 1; O_9 to O_{14} are the six water molecules of the asymmetric unit.

Fig. 1 represents a projection of the electron density on the $x0z$ plane; Fig. 2 is a projection of the structure on this same plane, while Fig. 3 is a projection of the structure on the plane $0yz$.

Even at this stage of refinement several conclusions can be drawn: (1) The arrangement of the phosphate group and the calcium atom relative to the two-fold screw axis is similar to that found by MacLennan and Beevers[17] for dicalcium phosphate. (2) All the atoms of thymine lie in a plane, essentially perpendicular to the b-axis. (3) The thymine molecules are packed together with their planes parallel to one another as in the model of deoxyribonucleic acid form B. Furthermore, the distance between the two bases ($b/2 = 3{\cdot}43$ A.) is nearly identical with that found in deoxyribonucleic acid (3·40 A.). (4) The sugar is in the normal gauche form; in addition, its plane is essentially perpendicular to the plane of the thymine residue, which confirms the result found by Furberg[12] for cytidine. (5) The structure is interlaced with a network of at least nine possible satisfactory hydrogen bonds, all but one of which involve at least one water molecule.

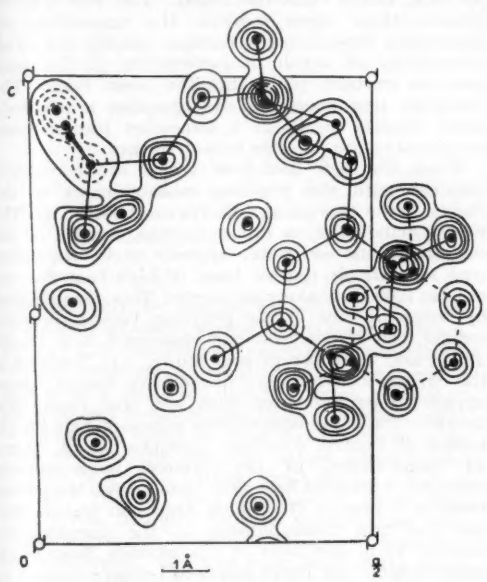


Fig. 1

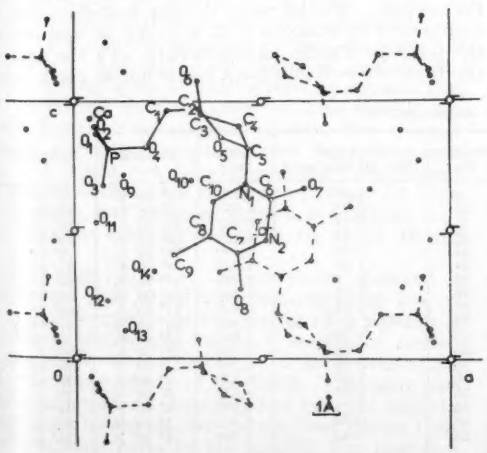


Fig. 2

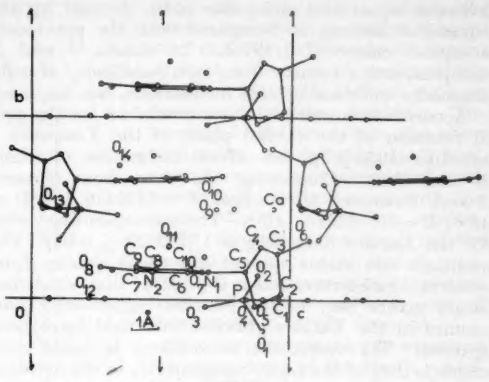


Fig. 3

We are grateful to the United States Office of Naval Research for support of the computer *Swac* upon which all the later stages of the present calculations were done.

P. Horn
V. Luzzati
Centre de Recherches sur les Macromolecules,
Strasbourg.

K. N. Trueblood
University of California,
Los Angeles. Feb. 11.

[1] Crick, F. H. C., and Watson, J. D., *Proc. Roy. Soc.*, A, **223**, 80 (1954).
[2] Clews, C. J. B., and Cochran, W., *Acta Cryst.*, **1**, 4 (1948).
[3] Clews, C. J. B., and Cochran, W., *Acta Cryst.*, **2**, 46 (1949).
[4] Pitt, G. J., *Acta Cryst.*, **1**, 168 (1948).
[5] White, N. E., and Clews, C. J. B., *Acta Cryst.*, **9**, 586 (1956).
[6] Broomhead, J. M., *Acta Cryst.*, **1**, 324 (1948).
[7] Cochran, W., *Acta Cryst.*, **4**, 81 (1951).
[8] Broomhead, J. M., *Acta Cryst.*, **4**, 92 (1951).
[9] Parry, G. S., *Acta Cryst.*, **7**, 313 (1954).
[10] Sutor, D. J., *Acta Cryst.*, **11**, 83 (1958).
[11] Sutor, D. J., *Acta Cryst.*, **11**, 453 (1958).
[12] Furberg, S., *Acta Cryst.*, **3**, 325 (1950).
[13] Huber, M., *Acta Cryst.*, **10**, 129 (1957).
[14] Brown, D. M., Fasman, G. D., Magrath, D. I., Todd, A. R., Cochran, W., and Woolfson, M. M., *Nature*, **172**, 1184 (1953).
[15] Spencer, M., *Acta Cryst.*, **12**, 59 (1959).
[16] Sparks, R. A., Prosen, R. J., Kruse, F. H., and Trueblood, K. N., *Acta Cryst.*, **9**, 350 (1956).
[17] MacLennan, G., and Beevers, C. A., *Acta Cryst.*, **8**, 579 (1955).

PHYSICAL SCIENCES

A New Value for the Earth's Flattening, derived from Measurements of Satellite Orbits

In a recent article[1] in *Nature*, we described how the Earth's gravitational field could be explored with the aid of satellites, and gave some results obtained from analysis of kinetheodolite observations of *Sputnik* 2 (1957β), the orbit of which was inclined to the equator at an angle near 65°. From observations of a single satellite, the coefficient J of the second harmonic in the Earth's gravitational potential could only be evaluated if the coefficient D of the fourth harmonic were given its conventional value of $10{\cdot}6 \times 10^{-6}$. On this assumption the value derived[1] for J was 1626×10^{-6}, corresponding to a value of 1/298·1 for the Earth's flattening (defined as the difference

between equatorial and polar radii, divided by the equatorial radius), as compared with the previously accepted value[3] of 1/297·1. To obtain J and D independently, results from two satellites, of substantially different orbital inclinations, are required.

Accurate information is now available[3] for the rate of rotation of the orbital plane of the *Vanguard* 1 satellite (1958 β 2), the orbital inclination of which is near 34°. Combining the data from *Sputnik* 2 and *Vanguard* 1, we find $J = (1624{\cdot}6 \pm 0{\cdot}3) \times 10^{-6}$, $D = (6 \pm 1) \times 10^{-6}$. The corresponding value for the Earth's flattening is $1/(298{\cdot}20 \pm 0{\cdot}03)$. The standard deviations quoted are those arising from observational errors, and it is possible that somewhat larger errors may occur, because higher-order harmonics in the Earth's gravitational field have been ignored. The coefficient most likely to cause such errors is that of the sixth harmonic, J_6 in the notation of our previous article. We have now made a preliminary estimate of J_6 with the aid of the information so far available on *Explorer* 4 (1958ε), the inclination of which is near 50°, and find $J_6 = (0{\cdot}1 \pm 1{\cdot}5) \times 10^{-6}$: this causes no significant change in the values of J, D and flattening already quoted. Nor is there any significant change if the coefficient of the third harmonic J_3, derived recently[4] from perturbations to the orbit of *Vanguard* 1, is taken into account.

D. G. King-Hele
R. H. Merson

Royal Aircraft Establishment,
Farnborough, Hants. Feb. 25.

[1] Merson, R. H., and King-Hele, D. G., *Nature*, **182**, 640 (1958).
[2] Jeffreys, H., "The Earth", third edit. (Camb. Univ. Press, 1952).
[3] Jacchia, L. G., Smithsonian Astrophysical Observatory Special Report No. 19, 1 (1958).
[4] O'Keefe, J. A., Eckels, A., and Squires, R. K., "Shape of the Earth from the Analysis of Vanguard Data", *U.S. National Aeronautics and Space Administration* publication (1959).

Heat-Flow Values from the South-Eastern Pacific

Prior to these new measurements, twenty-five heat-flow values from the Pacific Ocean Basin and eight from the Atlantic have been published[1]. The surprising fact brought out by these measurements is the approximate equality of average heat flow of the oceanic and continental areas, about 1×10^{-6} cal./cm.^{2} sec. This result was unexpected on the basis of values of radioactivity indicated for typical continental and oceanic crustal rocks existing near the Earth's surface. It has usually been assumed that most of the surface heat flow in continental regions must originate in the relatively thick and radioactive continental crust. Under the oceans, nearly all the average heat flow must come from the mantle beneath the relatively thin oceanic crust.

The new heat-flow values from the Pacific were obtained during October 1957–February 1958 on the Scripps Institution of Oceanography *Downwind* International Geophysical Year Expedition. The measurements are listed in Table 1, and the geographical distribution of stations, with generalized 4,000- and 5,000-m. bottom-depth contours of the area, is shown in Fig. 1. The topography was kindly supplied by Dr. Henry Menard of the Scripps Institution of Oceanography. The field technique was to measure the temperature gradient in the upper few metres of ocean floor sediment with apparatus first described by Revelle and Maxwell[2], and also the thermal conductivity of a cored sample of this sediment by a transient method[1]. The resulting heat-flow values are most probably accurate within 10 per cent, unless otherwise noted. The 'less than' or 'greater than' signs indicate the uncertainty of imperfectly functioning apparatus, usually due to an uncertainty of depth of penetration of the temperature gradient probe into the ocean floor. The thirty-six new measurements comprise a relatively more detailed study in a somewhat limited area, compared to the previous measurements.

When the new heat-flow values are considered together with the previous measurements in the Pacific, some interesting features can be seen. (1) The *East Pacific Rise*, a broad elevated region of the eastern Pacific sea floor, appears to be associated with a relatively narrow band of high heat flow for at least 6,000 km. along its length. This was indicated by three stations of the previous Pacific measurements[1], and is represented by stations 7, 8, 9, 10, 27, 29, 31 and 32 of the present study. (2) The axes of the trenches bordering the eastern Pacific Ocean appear to be associated with low heat flow. The previous Pacific measurements indicated this for the trench off Central America. Stations 18, 19, 20 and 21 respectively, of the present measurements, represent a series of heat-flow values down the eastern flank of a part of the South American trench, with the last two measurements in the deepest part. Station 17 is just west of the western flank of the same trench. (3) There seems to be fair evidence for areas with low heat flow roughly paralleling, and to each side of, the high heat-flow band of the East Pacific Rise. To the west, the low heat-flow area is represented by stations 1, 2, 5, 6, 35, 36 and one of the previous Pacific measurements. To the east of the Rise, the evidence for a low is not as good, being

Table 1. Heat-Flow Measurements

Station No.	Heat flow (10^{-6} cal./cm.^{2} sec.)	Depth (m.)	Latitude	Longitude	Station No.	Heat flow (10^{-6} cal./cm.^{2} sec.)	Depth (m.)	Latitude	Longitude
1	0·14	4,450	1° 23′ S.	131° 31′ W.	19	1·07	3,700	12° 54′ S.	78° 06′ W.
2	0·52 < Q < 0·78	4,510	14° 59′ S.	136° 01′ W.	20	0·17	5,950	12° 38′ S.	78° 38′ W.
3	0·97	4,760	21° 40′ S.	147° 41′ W.	21	0·17	5,900	12° 59′ S.	78° 21′ W.
4	1·1	5,120	40° 37′ S.	132° 52′ W.	22	0·26	4,220	18° 26′ S.	78° 16′ W.
5	0·14	4,620	42° 16′ S.	125° 50′ W.	23	0·98	3,090	18° 20′ S.	79° 21′ W.
6	0·73	4,140	46° 44′ S.	123° 18′ W.	24	1·02	4,230	19° 01′ S.	81° 29′ W.
7	2·06	3,180	44° 27′ S.	110° 44′ W.	25	2·12	3,880	27° 04′ S.	88° 53′ W.
8	3·06	3,180	43° 43′ S.	107° 33′ W.	26	0·23	3,200	28° 00′ S.	96° 20′ W.
9	2·09	3,850	43° 44′ S.	104° 25′ W.	27	4·54	2,910	27° 55′ S.	106° 57′ W.
10	2·30	4,580	42° 44′ S.	96° 03′ W.	28	1·84 < Q < 1·89	3,500	23° 15′ S.	117° 48′ W.
11	1·0	3,310	41° 06′ S.	86° 38′ W.	29	7·66	3,060	14° 44′ S.	112° 06′ W.
12	>0·89	4,110	28° 23′ S.	72° 10′ W.	30	1·01	3,580	13° 30′ S.	108° 31′ W.
13	0·80	3,750	28° 28′ S.	72° 58′ W.	31	8·09	3,280	11° 39′ S.	109° 48′ W.
14	1·62	4,550	21° 33′ S.	79° 09′ W.	32	7·95	2,840	9° 55′ S.	110° 39′ W.
15	0·79	2,340	20° 49′ S.	81° 08′ W.	33	0·87	4,040	5° 56′ S.	112° 29′ W.
16	1·54	2,400	20° 48′ S.	81° 09′ W.	34	1·71	4,330	3° 40′ S.	114° 13′ W.
17	1·46	4,440	13° 35′ S.	79° 09′ W.	35	0·56	3,810	1° 28′ N.	116° 04′ W.
18	2·72	2,260	12° 49′ S.	77° 53′ W.	36	0·43	4,200	4° 06′ N.	115° 41′ W.

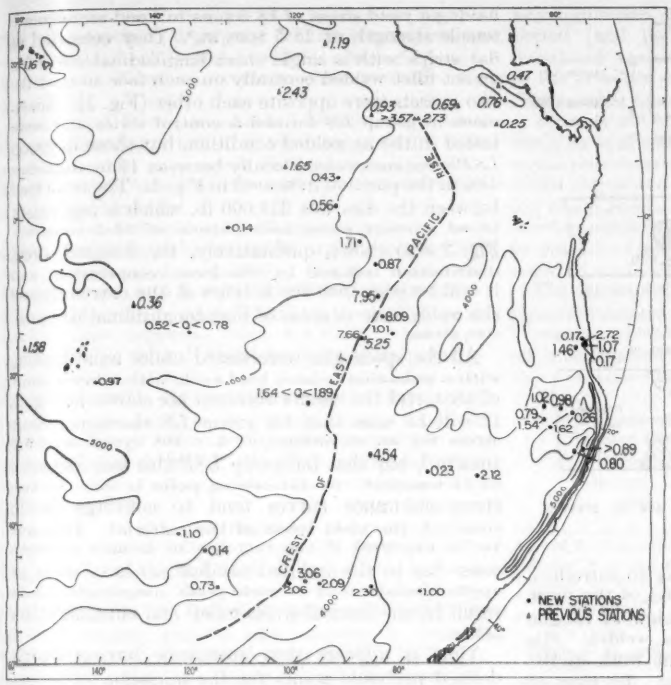


Fig. 1

represented only by station 26 and several of the previous Pacific measurements off the coast of Central America. The number of heat-flow measurements is not yet sufficient to establish how the trenches fit this general pattern; but the rough parallelism of the Rise and trenches may suggest a relationship.

An interesting result of these measurements is the extreme range of the heat-flow values, which extend from a low of $0{\cdot}14 \times 10^{-6}$ cal./cm.^{2} sec. to a high of $8{\cdot}00 \times 10^{-6}$ cal./cm.^{2} sec., a ratio of more than 1:50. Even though the area studied has large topographic features, where differences of heat flow might be expected, the large magnitude of the range of heat flow is somewhat surprising. It is believed that some of the variation in heat flow may be due to irregularities in bottom topography, or to an irregular surface of rocks of good thermal conductivity buried by a smooth sediment surface, as suggested previously[1]. Although it is difficult to evaluate the combined magnitude of these effects, it appears that they would not alter the observed heat flow at any station from the assumption of heat flow through uniform, horizontal layers by more than a factor of two, and would not be systematically distributed. The measurements have not been corrected for these disturbances, but irregular bottom topography may have had some effect on stations 6, 10, 11, 15, 16, and 30.

Undoubtedly, most of the variations observed in oceanic heat flow are due to differences in flow of heat from the mantle of the Earth. The pattern of heat flow in the eastern Pacific, if verified by further measurements, is suggestive of a large convective cell in the upper mantle of the Earth. The rising part of the convection cell, bringing hot material near the surface, may be represented by the East Pacific Rise, and the sinking parts by the possible low heat-flow areas on each side. Indeed, the lowest heat flows measured may be due entirely to the small amount of heat generated by radioactivity in the crust, with little or no heat coming from the mantle. The oceanic heat-flow values also show variations of relatively small horizontal extent not associated with topographic variations or with the large pattern, suggesting smaller-scale thermal anomalies in the mantle, perhaps also due to convection. A more closely spaced series of measurements in one of these areas is highly desirable.

Similar patterns may be expected for other areas of the Earth; high heat flow has been indicated also for the mid-Atlantic Ridge (Sir Edward Bullard, personal communication), a topographic feature of the Atlantic Basin similar to the East Pacific Rise. However, since convection could be driven by a deep distribution of radioactive heat sources under the ocean areas, it may be that similar patterns would not be observed in continental regions, where the radioactivity may be frozen uniformly in a relatively shallow crust. In fact, while the average heat flow seems to be about the same over continental and oceanic regions, the continental values show considerably less variation than the oceanic. However, this may result from a more limited distribution of continental heat-flow values; in fact, some areas of continents have been recently investigated which show unusually high heat flow[3,4]. Many problems have yet to be solved, and towards this end it is hoped that the results herein will be a stimulus for further measurements.

The measurements were made possible with the facilities of the Scripps Institution of Oceanography, and the interpretation of field observations was facilitated by a grant from the Institute of Geophysics, University of California. I wish to thank Prof. R. W. Raitt for encouraging the investigation and for many helpful discussions.

R. Von Herzen

Scripps Institution of Oceanography,
La Jolla, California.

Feb. 13.

[1] Bullard, E. C., Maxwell, A. E., and Revelle, R., "Adv. in Geophys.", 3, 153 (1956).
[2] Revelle, R., and Maxwell, A. E., *Nature*, 170, 199 (1952).
[3] Misener, A. D., *Trans. Amer. Geophys. Union*, 38, 1055 (1955).
[4] Boldizsar, T., *Geofisica Pura e App.*, 39, 120 (1958).

Improvement of the Fatigue Strength of Notched Specimens by artificially induced Residual Stresses

The question of whether or not residual stresses have any significant effect on fatigue strength has been the subject of much research for some time. However, in 1956 Puchner[1] showed that a large increase in the fatigue strength of specimens containing discontinuous longitudinal welds could be obtained by heating the specimen locally with an

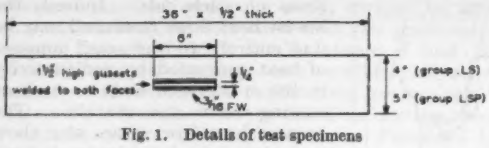
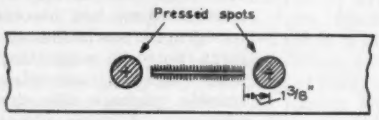
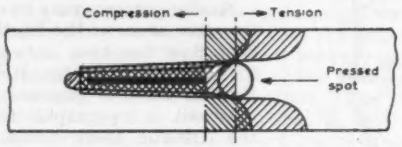


Fig. 1. Details of test specimens



(a) Positions of compressed areas.



(b) Qualitative residual stress distribution due to pressing

Fig. 2

oxyacetylene torch, in such a way as to introduce residual compressive stresses at the site of the most dangerous notch from the point of view of fatigue failure (namely, at the ends of the welds). His results have been confirmed by recent work of the British Welding Research Association. In view of the potential practical importance of these results, it was decided to carry out an exploratory programme of tests to determine the effect of inducing residual stresses by mechanical means.

The specimens used in this investigation were fabricated from mild steel to British Standard 15, having a yield stress of 18·0 tons/in.² and an ultimate tensile strength of 28·5 tons/in.². They consisted of flat strips with a single short longitudinal stiffening gusset fillet welded centrally on each face so that the two gussets were opposite each other (Fig. 1). Specimens in group *LS* formed a control series and were tested in the as-welded condition, but those in group *LSP* were compressed locally between 1¾-in. diameter dies in the position indicated in Fig. 2. The total load between the dies was 315,000 lb. which is equivalent to an average compressive stress of 58·5 tons/in.². Fig. 2 also shows, qualitatively, the residual stress distribution induced by the local compression, and it will be seen that the notches at the extremities of the welds were in areas of high longitudinal compressive stress.

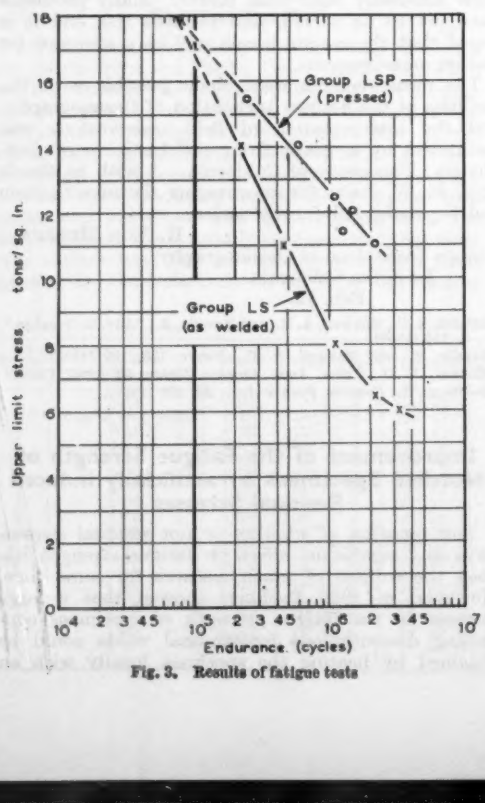


Fig. 3. Results of fatigue tests

All the specimens were tested under axial loading with a pulsating tension load cycle with a lower limit of zero, and the results obtained are shown in Fig. 3. It will be seen that for group *LS* the upper limit stress for an endurance of 2×10^6 cycles was 6·5 tons/in.², but that for group *LSP* this was increased to 11 tons/in.². An interesting point is that the two stress–endurance curves tend to converge at 18 tons/in.², the yield stress of the material. This was to be expected if the increase in fatigue strength were due to the induced residual stresses, since an applied tensile load of yield-point magnitude would result in 'mechanical stress relief' and eliminate their effects.

Thus it appears that specimens having clearly defined probable points for the initiation of fatigue failure can have their fatigue strength increased by compressing an area adjacent to the notch to such an extent that residual stresses are induced. The compressed area should be chosen so that the residual radial compressive stresses act in the same direction on the notch as the applied stresses. Further work is proceeding on this subject and this will be published elsewhere in due course.

T. R. Gurney

British Welding Research Association,
Abington Hall,
Abington,
Cambridge.
Dec. 17.

[1] Puchner, O., *Schweisstechnik*, **6**, No. 4 (1956).

Thermal Decomposition of Irradiated Solids

The thermal decomposition, *in vacuo*, of potassium permanganate[1] and silver permanganate[2] crystals is markedly affected by pre-irradiation in *Bepo* or in a cobalt-60 hot-spot. The induction periods are shortened and the maximum velocities are increased. A mechanism has been suggested involving the growth of decomposition spikes and the accumulation of strain in the crystal over the induction period.

Similar work in progress in these laboratories has shown that cæsium and rubidium permanganates are affected in a like manner. However, pre-irradiation of silver oxide[3] in *Bepo* in a position near the outside (thermal neutron flux, 2×10^{11} n./cm.²/sec.) for 48 hr., in a hollow uranium slug (fast neutron flux, 3×10^{11} n./cm.²/sec.) for one week, and in a cobalt-60 hot-spot (dose-rate, $1{\cdot}6 \times 10^6$ rep hr.$^{-1}$) for 48 hr., produced no effect on the subsequent thermal decomposition; the pressure – time curves of irradiated and unirradiated specimens were almost superimposable.

Insufficient work has, as yet, been done in this field of research to draw any definite conclusions as to the class of solids which will be affected by pre-irradiation. However, certain characteristics are observable.

Garner and Moon[4] bombarded barium azide with the radiations from radium at room temperature with no effect on the subsequent thermal decomposition. Similarly, they found no effect on the decomposition of mercury fulminate.

Bowden and Singh[5] subjected lithium azide, lead azide, silver azide, cadmium azide, and silver acetylide to bombardment by electrons, thermal neutrons, fission products, and X-rays. The thermal decomposition of lithium azide was effected by thermal neutron bombardment (approx. dose, $2{\cdot}5 \times 10^{11}$ nvt) in a manner similar to that found for potassium permanganate, whereas cadmium and lead azides were only slightly affected. The published results for the last two substances, however, do not indicate the degree of reproducibility of results and the change could be due to experimental variation. No effect was found in the decomposition of silver azide. This substance melts on decomposition.

Simpson *et al.*[6] pre-irradiated ammonium dichromate with cobalt-60 γ-rays for four months. The intensity of the radiation was not given, but was stated to be low. The subsequent thermal decomposition showed an induction period only slightly less than normal, and the rate constant, k_1, for the acceleratory region changed from 0·0175 to 0·023, as calculated from the Prout–Tompkins equation[7], $\log_{10} p/(p_f - p) = k_1 t + c_1$, where p_f is the final pressure. The decompositions were stated to be reproducible to within only 20 per cent and it appears possible that this last difference might be attributed to other factors.

Flanagan[8] subjected lead styphnate monohydrate to a γ-ray dose of $1{\cdot}8 \times 10^8$ r. from cobalt-60 and found no effect on the thermal decomposition. Reactor irradiation, however, greatly affected the subsequent decomposition—the maximum rate of decomposition was increased three-fold by a neutron dose of $2{\cdot}2 \times 10^{18}$ nvt. The absence of any effect by γ-ray irradiation and the fact that significant changes were obtained only after heavy doses of neutrons ($> 10^{17}$ nvt) would suggest an irradiation effect different from that found with the permanganates where a dose of only 6×10^{13} nvt caused pronounced changes in the thermal decomposition.

The pressure–time plots of potassium, silver, cæsium, and rubidium permanganates and ammonium dichromate can be represented by the Prout–Tompkins equation or a modification of this equation[9]. The decomposition mechanisms associated with these equations involve the concept of branching chains. No analysis was given by Bowden and Singh of the pressure–time curves for lithium azide, but using the values obtained from a photographic enlargement of the published curve a good fit is obtained by the application of the Prout–Tompkins equation.

The power law, $p = k_2 t^n + c_2$, is obeyed for the decompositions of lead azide, lead styphnate monohydrate, mercury fulminate, silver oxide, and barium azide. Growth of nuclei in these cases is presumed to be normal and the effect of possible overlap between growing nuclei is not considered.

The theory proposed for the decomposition of irradiated potassium and silver permanganates postulates the displacement of potassium and silver ions into interstitial positions. The failure to observe any significant change in the length of the induction period (and perhaps k_1) in the decomposition of irradiated ammonium dichromate is due, possibly, to the presence of the more complex and not directly displaceable ammonium ion.

Thus, it would seem that the substances which are likely to be affected by pre-irradiation in the same way as the permanganates will be those containing a simple metal cation and decomposing according to a branching chain mechanism. Another requirement is that the decomposition spikes should create strain sufficient to crack or fracture the solid and thus create new, reactive surfaces.

The decomposition of lead oxalate[10] yields a typical sigmoid pressure–time curve which obeys the Prout–Tompkins equation. In view of the above observations an investigation of the effects of pre-irradiation on this substance is in progress.

E. G. Prout

Department of Chemistry,
Rhodes University,
Grahamstown,
South Africa.

Feb. 9.

[1] Prout, E. G., *J. Inorg. Nucl. Chem.*, **7**, 368 (1958).
[2] Prout, E. G., and Sole, M. J., *J. Inorg. Nucl. Chem.* (in the press).
[3] Herley, P. J., and Prout, E. G. (being prepared for publication).
[4] Garner, W. E., and Moon, C. H., *J. Chem. Soc.*, 1398 (1933).
[5] Bowden, F. P., and Singh, K., *Proc. Roy. Soc.*, A, **227**, 22 (1954).
[6] Simpson, J., Taylor, D., and Anderson, D. M. W., *J. Chem. Soc.*, 2378 (1958).
[7] Prout, E. G., and Tompkins, F. C., *Trans. Farad. Soc.*, **40**, 488 (1944).
[8] Flanagan, T. B., *Nature*, **181**, 42 (1958).
[9] Prout, E. G., and Tompkins, F. C., *Trans. Farad. Soc.*, **42**, 482 (1946).
[10] Bircumshaw, L. L., and Harris, I., *J. Chem. Soc.*, 1898 (1948).

Errors caused by Partial Drying of Hardened Portland Cement during Testing

It is known that incorrect estimates of the modulus of rupture and tensile strength may be obtained if Portland cement mortar or concrete specimens awaiting test are allowed to dry partially. Strength changes have also been observed when pozzolana-lime cement specimens begin to dry out[1], and, similarly, it has been demonstrated[2] that temporary reductions can develop in the modulus of rupture of road-making concretes, over a period of days, if the hardened mass is subjected to drying conditions.

The purpose of this communication is to emphasize the extreme magnitude of the change in strength which can be caused by partial drying of hydrated Portland cement, and to direct attention to the great rapidity with which this change can occur.

The results given here were obtained with small Portland cement paste prisms of ¼-in. square cross-section, which had been cured for an initial 24 hr. in the moulds, and afterwards under water at 73° F. until tested at 56 days. A type 1 high alkali Portland cement was used at a water/cement ratio of 0·28 by weight. The results came from tests carried out at a temperature of approximately 75° F., in a laboratory which was not air-conditioned. The relative humidity was low at the time. The moduli of rupture given in Table 1 were obtained as follows.

Each row of results was obtained with specimens removed from the curing water at the same time. Since each test occupied 45–60 sec., the figures in column (*a*) are for specimens the surfaces of which had dried for not more than 1 min.; those in column (*f*) apply to specimens which had been exposed for 4½–6

Table 1. Modulus of Rupture (lb./in.²) of Portland Cement Paste at 56 Days

	a	*b*	*c*	*d*	*e*	*f*
1	1,040	910	1,000	980	1,040	—
2	1,380	1,110	1,140	900	—	—
3	1,750	970	1,050	910	1,090	990
4	1,960	1,930	1,790	2,200	2,300	—
5	1,670	2,310	2,150	1,840	1,860	1,950
6	1,730	2,020	2,000	1,750	1,770	—

min. It was observed that specimens 2*a* and 3*a*, which were tested with the very minimum of delay, apparently had higher strengths than the other prisms in rows 1–3. Since differential drying shrinkage was considered a possible cause of this behaviour, the remaining experiments (rows 4–6 inclusive) were completed with the prisms immersed in a water-bath at 75° F. during testing. A mean modulus of rupture of 1,960 lb./in.² and coefficient of variation of 10 per cent was obtained with immersed specimens. This compares with a mean of 1,010 lb./in.² and coefficient of variation of 8 per cent for tests performed after more than 1 min. of exposure in the air of the laboratory.

Equally large strength reductions have since been observed in additional experiments with 3 in. × 3 in. × 18 in. Portland cement paste beams which were allowed to dry for a short period in the air of the laboratory prior to testing.

K. M. Alexander*

Stanford Research Institute,
Menlo Park,
California.
Feb. 10.

* Present address: Cement and Ceramics Section, Chemical Research Laboratories, Commonwealth Scientific and Industrial Research Organization, G.P.O. Box 4331, Melbourne C.1.

[1] Alexander, K. M., and Wardlaw, J., *Austral. J. App. Sci.*, **6** (1), 46 (1955).
[2] Graf, O., *Strassenbautagung*, 157 (1938).

CHEMISTRY

Structure of Glass

I have shown[1,2] that there is a linear relation between the volume v associated with an oxygen ion in a glass and the composition of the glass. The relation for simple soda–silica glasses is:

$$v = 3{\cdot}8R + 14{\cdot}9 \qquad (1)$$

and for simple potash silica glasses:

$$v = 12R - 1{\cdot}2 \qquad (2)$$

where R is the number of oxygen ions per network-forming atom. v is modified by the introduction of a third oxide into soda or potash glass. Introduction of a network-forming oxide should be allowed for in the calculation of R and then v can be obtained from equations (1) or (2) with a slight modification of the additive constant (15·1 for glasses containing alumina and 14·6 for those containing beryllia). Boron trioxide causes a further correction and then:

$$v = 3{\cdot}8R - 2\mathrm{Na}^* + 14{\cdot}65 \qquad (3)$$

Chemical symbols with an asterisk denote the number of gram-ions in 100 gm. of glass.

Introduction of certain cations in soda or potash glass contracts or expands the network proportionally to the concentration, each oxide having its own factor, which is constant over a wide range of compositions. The factors are different for soda and potash glasses, but they remain constant when several substances are introduced, that is, they do not influence each other. The factors in Table 1 have been determined.

Table 1

Ion	Radius (A.)	Factor for soda glass	Factor for potash glass
Li^+	0·70	− 2·4	−12
Na^+	0·98	0	− 2
K^+	1·33	+ 4	0
Rb^+	1·49	—	+ 4
Mg^{2+}	0·78	− 5	−13
Ca^{2+}	1·06	− 5	−12
Sr^{2+}	1·22	− 3	—
Ba^{2+}	1·43	− 0·5	− 9
Zn^{2+}	0·83	− 2	—
Pb^{2+}	1·32	+ 0·5	− 9
Fe^{2+}	0·83	− 4	—
Fe^{3+}	0·63	− 6·5	—
Bi^{3+}	1·24	− 9	—
Ti^{4+}	0·65	−11	—
Zr^{4+}	0·77	−10	—
Ta^{5+}	0·68	—	−36

The complete equation for glasses with a soda basis is therefore:

$$v = 3{\cdot}8R - 2{\cdot}4\mathrm{Li}^* + 4\mathrm{K}^* - 5\mathrm{Mg}^* - 5\mathrm{Ca}^* - 3\mathrm{Sr}^* - 0{\cdot}5\mathrm{Ba}^* - 2\mathrm{Zn}^* + 0{\cdot}5\mathrm{Pb}^* - 4\mathrm{Fe}^{II*} - 6{\cdot}5\mathrm{Fe}^{III*} - 9\mathrm{Bi}^* - 11\mathrm{Ti}^* - 10\mathrm{Zr}^* + 14{\cdot}9 \qquad (4)$$

and for glasses with a potash basis:

$$v = 12R - 12\mathrm{Li}^* - 2\mathrm{Na}^* + 4\mathrm{Rb}^* - 13\mathrm{Mg}^* - 12\mathrm{Ca}^* - 9\mathrm{Ba}^* - 9\mathrm{Pb}^* - 1{\cdot}2 \qquad (5)$$

It can be seen that the smaller the radius and the larger the valency of the ion, the greater its contracting effect; an expanding effect is rarer and is larger for an ion with smaller valency. The contraction of potash glasses, which have considerably larger v values, is much larger than that of soda glasses. The effect of ions which do not have a noble gas structure is smaller.

Calculations have been made for more than 500 glasses, including a few with 8 and one with 9 components. The largest discrepancy is 1·5 per cent; in most cases it is a few tenths of 1 per cent.

From the results in Table 1 we can deduce that:

(1) Li^+ is not a network-forming ion, but a modifier; otherwise the calculations do not give a reasonable value for v (lithium oxide content 0–15 per cent).

(2) Zn^{2+}, Ti^{4+} and Zr^{4+} are also modifiers (titanium dioxide content 2·04–9·89 per cent, zinc oxide content 1·29–11·39 per cent, zirconium dioxide content 2·67–20·96 per cent).

(3) Be^{2+} is a network-former (beryllium oxide content 4·78–30·95 per cent).

(4) Al^{3+} is also a network-former (aluminium oxide content 0–25·3 per cent).

No ion has been found to have an intermediate behaviour.

These conclusions are confirmed by a calculation of the thermal expansion coefficients (α) on a new basis. It is well known that α can be calculated roughly by adding together the oxide percentages multiplied by appropriate factors. A number of different sets of factors exist[3,4], but none of them gives satisfactory results if used for widely differing glasses; the differences between measured and calculated values sometimes amount to more than 10 per cent and they are quite useless for borosilicate glasses. A new equation is suggested for the coefficient of linear expansion, which contains an additive constant besides the oxide percentages multiplied by new factors; the additive constant varies somewhat

with temperature (this has scarcely been considered by former investigators). The new equation, between 0° and 100° C., is :

$$10^6\alpha = 100(Li_2O) + 35(Na_2O) + 30(K_2O) - 8(MgO) + 10(CaO) + 8(BaO) + 6(PbO) + 4(Fe_2O_3) - 6(ZnO) - 6(ZrO_2) + A \quad (6)$$

where the additive constant A is 200 for common glasses (containing less than 5 per cent of lead, barium or zinc oxides), 280 for glasses with more than 5 per cent lead oxide, 220 for glasses with more than 5 per cent barium oxide and 250 for glasses with more than 5 per cent zinc oxide, between 0° and 100° C. The thermal expansion coefficients of more than 220 glasses have been calculated in this way ; the average error in the different series varies from 0·7 per cent to 2·2 per cent for boron-free glasses, 2·5 per cent for borosilicate glasses and 3·5 per cent for glasses containing titanium dioxide.

A very striking fact is that the thermal expansion is largely due to the alkali ions ; the effect of alkaline earth ions is small, while that of Fe^{3+}, Zn^{2+} and Zr^{4+} is even smaller. All other ions have a negligible influence on the thermal expansion ; the network-forming ions are without any effect. The oxides of beryllium and aluminium behave in this respect quite like silica, boron trioxide and phosphorus pentoxide.

The existence of a continuous non-periodic tetrahedral network seems to be indicated by these results, although the rigorous conditions proposed by Zachariasen[5] cannot be maintained in some cases.

I. Náray-Szabó

Central Chemical Research Institute,
Hungarian Academy of Science,
114 Hungária körut,
Budapest. Dec. 29.

[1] Náray-Szabó, I., *Nature*, **181**, 40 (1958).
[2] Náray-Szabó, I., *Acta Phys. Acad. Sci. Hung.*, **8**, 37 (1957); **9**, 151 (1958).
[3] Winkelmann, A., and Schott, O., *Ann. Phys.*, **51**, 735 (1894).
[4] English, S., and Turner, W. E. S., *J. Amer. Ceram. Soc.*, **10**, 551 (1927).
[5] Zachariasen, W. H., *J. Amer. Chem. Soc.*, **54**, 3841 (1932).

Estimation of Strontium in Animal Bone using X-ray Fluorescence Analysis

Previous work on strontium estimation in biological material has involved the use of optical emission spectroscopy[1] and flame spectrophotometry[2], both of which suffer from the disadvantage that the sample is destroyed during the analysis. This can be a significant factor when, in the interest of precision, the analysis must be repeated several times on each sample, when the quantity of material from any particular region of a bone is small, or when the sample is to be used for radiometric estimation of strontium-90.

X-ray fluorescence spectroscopy offers a fairly straightforward method for the estimation of strontium in animal bone, because the spectra of the major constituents, calcium and phosphorus, do not interfere with the strontium $K\alpha$ spectral line used in this analysis ; and any of the heavier elements which may interfere are present in such small concentration that their effects can be ignored.

As a consequence of these two factors, no internal comparison element is necessary, and a direct measurement of intensity on the strontium $K\alpha$ line is sufficient to give the concentration of strontium.

Discounting instrumental error, the accuracy of the method will depend upon obtaining the maximum intensity of the fluorescence radiation, and upon the absolute reproducibility of the method of specimen preparation. This latter factor ensures that variations in intensity of the strontium $K\alpha$ radiation are due to variations in concentration and not to differences in the specimen surface exposed to the incident beam.

To obtain these two requirements the following method of specimen preparation was evolved.

A 2-gram sample of bone ash was ground to − 200 mesh, 2 drops of flexible collodion added as a binder, and the whole ground in acetone to achieve a uniform distribution. The dried powder was then compressed in a suitably shaped die, using a sheet of polished high tensile steel for the working face of the specimen, to a pressure of eight tons. The resultant disk has sufficient strength to be self-supporting, and offers an exactly identical surface to the X-ray beam in every sample, giving the desired specimen reproducibility.

The high compression also ensures that a maximum quantity of material is available at the immediate surface for the generation of secondary radiation. Because the sample is self-supporting its surface can be placed directly in the primary beam ; no 'Mylar' film or other supporting medium is necessary. As a result the maximum intensity can be obtained.

The standards used in the construction of the working curve were made from human bone ash to which increments of strontium were added in the form of an aqueous solution of strontium nitrate, containing 0·2415 gm. in 100 ml. of water, giving a solution containing 1,000 p.p.m. To 19·9517 gm. of human bone ground to − 200 mesh was added 20 ml. of this solution. To achieve a uniform distribution of strontium, 100 ml. of acetone was added, and the whole mixed thoroughly until dry. This gave 20 gm. of bone ash containing 1,000 p.p.m. of strontium in addition to its normal strontium content.

This bulk material was diluted with bone ash to give 2-gm. standards of 100–800 p.p.m. in increments of 100 p.p.m., which were pressed into disks by the previously described method.

The intensities of the strontium $K\alpha$ line and background were measured for each sample. The intensity of the line was also measured in the same manner on a bone sample to which no strontium had been added. The intensity for the added strontium in each standard was then obtained by subtracting the background intensities and the strontium $K\alpha$ intensity of the bone standard.

The instrumentation used was : Philips X-ray spectrograph *PW*1520 ; quartz analysing crystal ; Geiger counter operating at 1,700 V. ; X-ray path evacuated ; tungsten target, 50 kV. 20 m.amp.

The method of 'constant accuracy' counting was used, and 32,000 counts were taken on both the strontium line and the background on each sample. At the intensities under consideration the dead-time losses for the counter are so small that they can be ignored.

From the data obtained a curve was plotted by the least-squares method, and the standard deviation for the individual readings calculated from the method described by Youden[3]. The curve is shown in Fig. 1. The standard deviation is 8 p.p.m. ; for 95 per cent confidence limits the standard deviation will be 16 p.p.m.

For the actual analyses the samples were run in triplicate, so that for 95 per cent confidence limits the standard deviation will be ± 10 p.p.m.

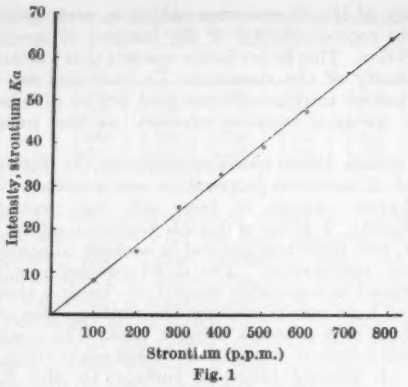


Fig. 1

Some results for bones of two adults labelled Adult 1 and Adult 2 are given in Table 1.

Table 1

Adult 1	Strontium (p.p.m.)	Adult 2	Strontium (p.p.m.)
Rib	286		
Vertebra	266		
Femur:		Femur:	
Epiphysis section *A*	281	Epiphysis section *A*	480
" " *B*	276	" " *B*	470
" " *C*	287	" " *C*	497
Shaft	291	Shaft	472

I wish to thank Dr. P. Ilbery, of the School of Public Health and Tropical Medicine, at whose request this investigation was carried out, for his co-operation throughout the project, Mr. W. J. Thomas, of the Bureau of Mineral Resources, for his valuable assistance in the statistical analysis, and Miss Horsford, of the School of Public Health and Tropical Medicine, for the careful preparation of the bone samples used in this work.

W. M. B. Roberts

Bureau of Mineral Resources,
Canberra.
Feb. 10.

[1] Thurber, D. L., *et al.*, *Science*, **128**, 3318 (1958).
[2] Harrison, G. E., *Nature*, **182**, 4638 (1958).
[3] Youden, W. J., "Statistical Methods for Chemists" (Wiley, 1955).

Micro Determination of Calcium

Hildebrand and Reilly[1] have recently described a complexometric titration method for the determination of calcium: the indicator used, 'Calcon', is superior to 'Solochrome' black in that calcium can be determined independently of magnesium, and, unlike the murexide method, a sharp end-point is obtained. All three methods employ ethylenediamine tetraacetic acid. The purpose of the present communication is to direct attention to the facts: (*a*) that the allied compound 1-(1-hydroxy-2-naphthylazo)-5-nitro-2-naphthol-4 sulphonic acid sodium salt (Eastman-Kodak) appears to be just as suitable as an indicator as 'Calcon' but is considerably cheaper; (*b*) that the method can also be used on an ultra-micro scale. Concentrations of the order of 10^{-2} μgm. calcium have been determined in volumes of about 40λ of solution with an accuracy of 1 per cent (1λ = 0·001 ml.).

Essentially, the method is similar to the original[1], and relatively the same quantity of buffer (diethylamine) is employed; in fact, it was found that the quantities of both buffer and indicator were critical. For 40λ of solution 1·75 ± 0·25λ of diethylamine maintained the required *p*H of 12–13, and accurate and repeatable results were obtained with 5 ± 0·5λ of indicator: these volumes were delivered with microburettes.

The cap of a 1-cm. 'attached-cap' polythene tube was found superior to a waxed slide for the titration: not only is the surface suitable, but also, lighted from below, the drop of solution is very suitably illuminated for observation of the end-point. The solution was brought into contact with the glass needle of the burette, a 100-λ pipette graduated in 1λ units (Glen-Creston, Ltd.), and titration continued until all trace of pink had disappeared and the solution turned pale blue[1]: at this stage the addition of 0·5λ of 0·0002 *N* ethylenediamine tetraacetic acid produced a marked change of colour. Stirring was carried out by a fine jet of air.

The stock solution of 0·02 *N* ethylenediamine tetraacetic acid keeps for many months without deterioration: however, the 0·0002 *N* solution prepared from it for titration was less stable and was therefore freshly prepared each week.

Determinations on twenty-one 40-λ samples containing $7{\cdot}96 \times 10^{-3}$ μgm. calcium diluted from a gravimetrically standardized solution gave a mean value of $7{\cdot}90 \pm 0{\cdot}80 \times 10^{-3}$; the difference is therefore less than 1 per cent from the expected value, and is far from statistical significance ($P > 0{\cdot}7$). Six or fewer determinations with a series of solutions of greater calcium concentration gave mean values which, as shown in Fig. 1, were also very close to those expected. Mean values were usually within 2 per cent, and never more than 4 per cent from the known values.

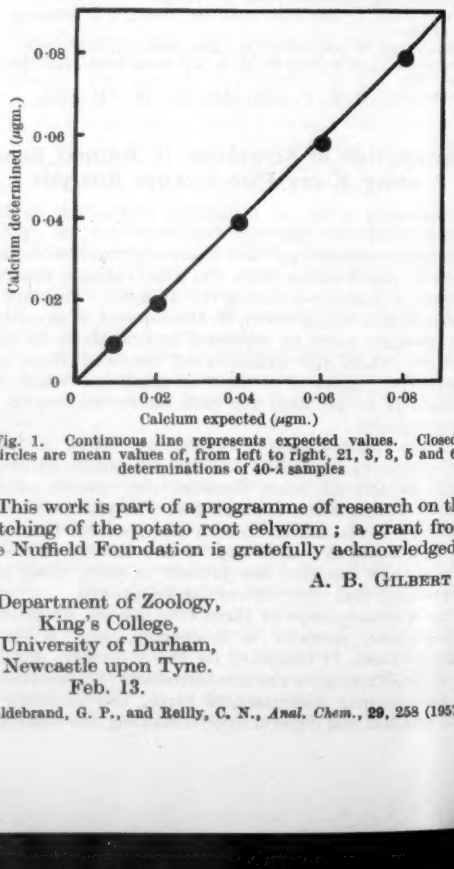


Fig. 1. Continuous line represents expected values. Closed circles are mean values of, from left to right, 21, 3, 3, 5 and 6 determinations of 40-λ samples

This work is part of a programme of research on the hatching of the potato root eelworm; a grant from the Nuffield Foundation is gratefully acknowledged.

A. B. Gilbert

Department of Zoology,
King's College,
University of Durham,
Newcastle upon Tyne.
Feb. 13.

[1] Hildebrand, G. P., and Reilly, C. N., *Anal. Chem.*, **29**, 258 (1957).

BIOCHEMISTRY

Production of Amide Groups and Ammonia in the Radiolysis of Aqueous Solutions of Protein

RECENT studies in this Laboratory have indicated[1,2] that a principal reaction in the radiolysis of aqueous solutions of protein under certain conditions involves cleavage of the peptide chain to form the carbonyl and amide functions as represented by the reaction :

$$—CO—NH—CH(R)— + O_2 + H_2O —\rightsquigarrow— —CONH_2 + RCO— + H_2O_2 \quad (1)$$

Evidence for this type of radiation-induced oxidation has been derived largely from studies of carbonyl production in oxygenated solutions of pepsin and gelatin. The carbonyl function is found to be associated with high molecular weight (non-dialysable) products which on conventional acid hydrolysis yield a series of α-keto acids. A correlation of these results in terms of a detailed mechanism for reaction (1) has been given elsewhere[2].

Substantiating evidence for the reaction as written has now been obtained from studies of the amide content of reaction products formed by γ-ray-induced oxidation of aqueous gelatin. Commercially available lime-process gelatin was found to be particularly suitable for this study since most of the amide groups of the glutamine and asparagine residues of the parent collagen are removed through hydrolysis during the manufacturing process[3]. Unmodified proteins, in general, contain amide groups in sufficient number to mask reaction (1) at the lower radiation dosages necessarily invoked in studies of initial reaction products.

Analyses were made for 'free' ammonia and for amide groups, both before and after irradiation. The stock solutions (3·5 per cent gelatin, purified calfskin, Eastman Lot 60-9680) had been previously dialysed to reduce the content of ammonia to a minimum value. Analytical procedures were, in brief, as follows : an appropriate aliquot of the solution was made alkaline to phenolphthalein and distilled at room temperature *in vacuo* into a receiver which contained 1 ml. of 0·1 *N* sulphuric acid at the temperature of liquid nitrogen. The distillate was isolated, thawed, and then assayed for ammonia by means of the Nessler reaction. A second aliquot of each solution was made 1 *N* in hydrochloric acid and heated for 1 hr. at 95° C. to liberate ammonia from amide linkages[4]. Subsequent treatment was then as described for ammonia. A series of control runs showed that the liberation of amide-ammonia was essentially quantitative under the mild hydrolysis conditions employed. Prolonged hydrolysis leads to the gradual breakdown of various labile amino-acids with the formation of what in this study would be 'artefact' ammonia[5,6]. An increase of 25 per cent in the number of amide groups in an irradiated solution as compared to the corresponding control solution could easily be observed with the method outlined above. Results shown in Table 1 were obtained on solutions that had been irradiated until the amide and ammonia content had reached values that were at least three times those of the control.

A 2,000-c. cobalt-60 γ-ray source was used in the irradiations. Solutions (10 ml.) were exposed under oxygen (5 ml.) at one atmosphere in sealed 'Pyrex' tubes. Contents were shaken at intervals to prevent depletion of oxygen in the solutions. The dose-rate was $2·5 \times 10^{18}$ eV./ml./min.

Table 1. PRODUCTION OF AMIDE GROUPS AND AMMONIA IN THE γ-RAY RADIOLYSIS OF AQUEOUS GELATIN SOLUTIONS

	Yield (G)*	
	Series 1	Series 2
Amide groups	1·0 ± 0·1	0·9 ± 0·1
Ammonia	0·25 ± 0·05	0·30 ± 0·05

* Yield per 100 eV. absorbed energy

The results in Table 1 indicate that the formation of amide groups ($G \simeq 1$) corresponds to a principal reaction in the radiolysis of aqueous solutions of gelatin. Further, the G value for this product-group is very close to that obtained for total carbony formation under equivalent irradiation conditions[2]. The simplest explanation for these results would seem to involve the postulated reaction (1). Ammonia formation ($G \simeq 0·3$) may be attributed to a radiation-induced oxidation of terminal and/or side-chain amino groups[7].

This work was performed under the auspices of the United States Atomic Energy Commission.

WINIFRED BENNETT
WARREN M. GARRISON

Crocker Laboratory,
Lawrence Radiation Laboratory,
Berkeley, California.
Jan. 8.

[1] Jayko, M. E., and Garrison, W. M., *Nature*, **181**, 413 (1958).
[2] Jayko, M. E., Weeks, B. M., and Garrison, W. M., Proc. Second Intern. Conf. on the Peaceful Uses of Atomic Energy, Paper 921 (United Nations, New York, 1958).
[3] Kenchington, A. W., and Ward, A. G., *Biochem. J.*, **58**, 202 (1954).
[4] Vickery, H. B., *J. Biol. Chem.*, **53**, 495 (1922).
[5] Springall, H. D., "The Structural Chemistry of Proteins", 227 (Academic Press, Inc., New York, 1954).
[6] Franck, B., and Knoke, J., *Chem. Ber.*, **90**, 2450 (1957).
[7] Weeks, B. M., and Garrison, W. M., *Rad. Res.*, **9**, 291 (1958).

Anion Inhibition of α-Glycerophosphate Dehydrogenase

RABBIT-muscle α-glycerophosphate dehydrogenase, which catalyses the reaction :

dihydroxyacetone phosphate + DPNH + H+ ⇌ α-glycerophosphate + DPN

was first crystallized by Baranowski[1]. More recently, Beisenherz *et al.*[2] and Young and Pace[3] have reported work in which this enzyme was studied with respect to a number of physical and chemical properties. In all cases where the above reaction was studied by measuring the reduction of dihydroxyacetone phosphate, this substrate had been prepared enzymatically[4]. In connexion with work on the metabolism of acetol phosphate (monohydroxyacetone phosphate)[5], dihydroxyacetone phosphate was prepared by the procedure described by Ballou and Fischer[6] and it was used in the experiments reported here. It was observed that dialysis of solutions of α-glycerophosphate dehydrogenase—which contained ammonium sulphate during preparation by the published procedure[3]—resulted in an appreciable loss of activity in some fractions (details of these experiments will be published elsewhere). Activities were determined by the spectrophotometric method of Beisenherz *et al.*[2]. When ammonium sulphate was added back

Table 1. Effect of Salts on the Activity of Dialysed α-Glycerophosphate Dehydrogenase

Salt added*	Percentage inhibition
None	0
Ammonium sulphate	65
Potassium sulphate	65
Sodium sulphate	67
Ammonium chloride	60
Potassium chloride	54
Sodium chloride	45
Ammonium formate	21
Ammonium formate†	40
Sodium formate	12
Sodium formate†	44
Ammonium sulphite	88
Sodium sulphite	85

For the measurement of the enzymatic activity, △ optical density (340 mμ) per 40 sec., the reaction mixture contained, in 3·0 ml. of total volume, dihydroxyacetone phosphate (1×10^{-4} *M*), reduced diphosphopyridine nucleotide (about $1{\cdot}5 \times 10^{-4}$ *M*), *tris*(hydroxymethyl) aminomethane buffer, *p*H 7·7 (4×10^{-1} *M*), α-glycerophosphate dehydrogenase (53 μgm., specific activity, 180), which was dialysed for 24 hr., and the salts listed below, to give the ionic strength indicated. In the control cuvette, reduced diphosphopyridine nucleotide was replaced by an equal volume of distilled water

* The ionic strength due to the addition of the salt was 0·19.
† Ionic strength was 0·57.

to the previously dialysed enzyme, a strong diminution of activity was noted as compared to activity of dialysed enzyme to which no ammonium sulphate was added. It was established, by comparing the effect of the corresponding sodium and potassium salts on the enzymatic activity, that this inhibitory effect was due to the anionic portion of the ammonium sulphate molecule. In addition, the ammonium, sodium and potassium salts of hydrochloric acid and the ammonium and sodium salts of formic and sulphurous acids were tested for an inhibitory effect.

Table 1 shows that, at an ionic strength of 0·19, *p*H 7·7, 24° C., the percentage inhibition of the enzymatic activity was a function of the particular anion tested. It can be seen also that an increase in ionic strength resulted in an enhancement of the observed inhibition in the case of formate. The influence of some sodium salts of different anions on the activity of α-glycerophosphate dehydrgoenase was then studied, and it was noted that, with the exception of glycine and ethylenediamine tetraacetate, all the anions tested exhibited inhibitory properties (Table 2). The ability of sulphite to inhibit α-glycerophosphate dehydrogenase was recently reported by Pfleiderer *et al.*[7], who observed that 20–50 μgm. of sulphite caused 25 per cent inhibition. The present results, in which 30 μgm. of sulphite ($3{\cdot}8 \times 10^{-4}$ *M*, Table 2) were shown to inhibit the dialysed enzyme by 17 per cent, are in good agreement with the findings of Pfleiderer *et al.*[7], who used undialysed enzyme preparations. It is of interest to note that the failure of glycine and ethylenediamine tetraacetate to inhibit α-glycerophosphate dehydrogenase, under the experimental conditions employed, bears resemblance to the results obtained by Theorell *et al.*[8] with liver alcohol dehydrogenase.

Table 2. Effect of Anions on the Activity of Dialysed α-Glycerophosphate Dehydrogenase

Anion	Final concentration of added salt (*M*)	Percentage inhibition
None	—	0
Acetate	$1{\cdot}9 \times 10^{-1}$	38
Bicarbonate	$1{\cdot}9 \times 10^{-1}$	65
Glycine	$1{\cdot}9 \times 10^{-1}$	0
Bromide	$2{\cdot}3 \times 10^{-1}$	55
Nitrate	$2{\cdot}3 \times 10^{-1}$	59
Azide	$5{\cdot}0 \times 10^{-3}$	14
Azide	$5{\cdot}0 \times 10^{-4}$	18
Azide	$5{\cdot}0 \times 10^{-5}$	22
Sulphite	$3{\cdot}8 \times 10^{-4}$	17
Sulphite	$3{\cdot}8 \times 10^{-3}$	33
Sulphite	$3{\cdot}8 \times 10^{-2}$	78
Sulphite	$6{\cdot}3 \times 10^{-1}$	85
Sulphate	$6{\cdot}3 \times 10^{-1}$	95
Phosphate	$4{\cdot}7 \times 10^{-1}$	52
Ethylenediamine tetraacetate	$1{\cdot}1 \times 10^{-4}$	0

The assay system, as described in Table 1, was used. The sodium salt solutions were adjusted to *p*H 7·5–7·9 prior to their addition to the cuvette

The observed high sensitivity of the dialysed α-glycerophosphate dehydrogenase to sulphate, an anion to which the enzyme is entirely stable prior to dialysis, may be tentatively explained by assuming that the prolonged dialysis causes the rupture of the bond between the nucleotide and the enzyme to which the nucleotide is known to be intimately bound[1,2]. This results in the exposure of active sites on the enzyme surface with a high but rather non-specific sensitivity to anions.

This work was supported by the Division of Grants and Fellowships, National Institutes of Health, U.S. Public Health Grant No. *H*-1525. The results were taken from a thesis submitted by Otto Z. Sellinger to the Graduate School of Tulane University in partial fulfilment of the requirements for the degree of doctor of philosophy.

Otto Z. Sellinger*
O. Neal Miller

Department of Biochemistry and the
Nutrition and Metabolism Research Laboratory
of the Department of Medicine,
Tulane University School of Medicine,
New Orleans.

* Present address: Department of Physiological Chemistry, University of Louvain.

[1] Baranowski, T., *J. Biol. Chem.*, **180**, 535 (1949).
[2] Beisenherz, G., Boltze, H. J., Bucher, T. H., Czok, R., Garbade, K. H., Meyer-Ardendt, E., and Pfleiderer, G., *Z. Naturforsch.*, **8B**, 555 (1953).
[3] Young, H. L., and Pace, N., *Arch. Biochem. Biophys.*, **75**, 125 (1958).
[4] Meyerhof, O., and Lohmann, K., *Biochem. Z.*, **271**, 89 (1934).
[5] Sellinger, O. Z., and Miller, O. N., *Biochim. Biophys. Acta*, **29**, 74 (1958).
[6] Ballou, C. E., and Fischer, H. O. L., *J. Amer. Chem. Soc.*, **78**, 1659 (1956).
[7] Pfleiderer, G., Jeckel, D., and Wieland, T., *Biochem. Z.*, **328**, 187 (1956).
[8] Theorell, H., Nygaard, A. P., and Bonnichsen, R., *Acta Chem. Scand.*, **9**, 1148 (1955).

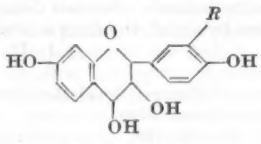
Flavan-3.4-diols and Leuco-anthocyanidins of *Guibourtia* spp.

Probably the most interesting of the large number of heartwood specimens previously examined[1] on two-way paper chromatograms by the toluene-*p*-sulphonic acid reagent[1,2] are the extractives of some of the species of the genus *Guibourtia*, previously known as *Copaifera*. Those extractives of *Guibourtia coleosperma*, *G. tessmannii* and *G. demeusei* which are soluble in methanol, for example, redden rapidly on exposure to direct sunlight and furnish high yields of anthocyanidins when treated with 3 *N* hydrochloric acid/propan-2-ol (1 : 5) under pressure[3] (about 8 per cent yield) or under anhydrous conditions with *N*/40 hydrochloric acid[4] (about 13 per cent yield). These extractives may be fractionated into a high proportion of tannins insoluble in water and with an average molecular weight of about 2,200, and a low proportion of polyphenols and carbohydrates soluble in water. Examination of the latter fraction with the

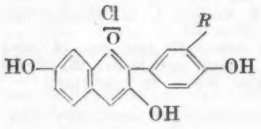
toluene-*p*-sulphonic acid spraying reagent on two-way paper chromatograms shows the probable presence of flavan-3.4-diols with R_F values corresponding to 0·45–0·55 in 2 per cent acetic acid (second irrigant), but with differing R_F values in the partitioning mixture used (butan-2-ol saturated with water: first irrigant)[5].

Two such compounds have been isolated in low yield, and were examined more closely as they appear to be directly related to the constitution of the highly condensed tannins present. Component I (R_F = 0·54 and 0·59 respectively) gives the same colour reactions and runs to the same position on two-way chromatograms as (+)-7.3′.4′-trihydroxyflavan-3.4-diol (mollisacacidin[6] and gleditsin[7]). Heating with alcoholic hydrochloric acid[3] affords a pink anthocyanidin, fisetinidin chloride (compound III, R = OH), and the compound undoubtedly is a 'leuco-fisetinidin' of structure I (R = OH).

Component II (R_F = 0·53 and 0·78 respectively) shows very weak reducing properties towards ammoniacal silver nitrate in the cold and its chromatographic behaviour in the partitioning mixture (R_F = 0·78) suggests that it has one hydroxyl group less than the accompanying 'leuco-fisetinidin' (R_F = 0·59)[8]. Furthermore, the weak reducing properties of II compared with I suggest that the new compound contains no vicinal hydroxyl groups on the *B* ring. Most significant, however, is its conversion in about 20 per cent yield into the yellow anthocyanidin, 3.7.4′-trihydroxyflavylium chloride[9] (compound IV, R = H) ($\lambda_{max.}$ = 490 mμ and R_F 0·60 in 3 *N* hydrochloric acid/90 per cent formic acid (1 : 1)). This and other evidence suggest that the compound has the structure 7.4′-dihydroxyflavan-3.4-diol (component II, R = H). This substance therefore appears to be the third member of the series of flavan-3.4-diols containing resorcinol, for example, leuco-robinetinidin[10], leuco-fisetinidin[6,11] and 7.4′-dihydroxyflavan-3.4-diol. The trivial names guibourtacacidin and guibourtinidin are proposed for the new leuco-anthocyanidin (component II, R = H) and for the anthocyanidin (compound IV, R = H)[9] generated from II respectively.



I, R = OH
II, R = H



III, R = OH
IV, R = H

Significance is attached to the observation that where these flavan-3.4-diols are present in *Guibourtia* species, the high molecular weight tannins which accompany them furnish high yields of both fisetinidin and guibourtinidin chlorides.

Further work on these compounds is in progress and will be published elsewhere.

D. G. Roux

Leather Industries Research Institute,
Rhodes University,
Grahamstown. Nov. 6.

[1] Roux, D. G., and Evelyn, S. R., *Biochem. J.*, **69**, 530 (1958).
[2] Roux, D. G., *Nature*, **180**, 973 (1957).
[3] Pigman, W., Anderson, E., Fischer, R., Buchanan, M. A., and Browning, B. L., *Tech. Assoc. Pulp and Paper Indust.*, **36**, 4 (1953).
[4] Roux, D. G., *Nature*, [**183**, 42 (1959)].
[5] Roux, D. G., and Evelyn, S. R., *J. Chromatography*, **1**, 537 (1958); *Biochem. J.*, **70**, 334 (1958).
[6] Koppler, H. H., *J. Chem. Soc.*, 2721 (1957).
[7] Mitsuno, M., and Yoshizaki, M., *J. Pharm. Soc. (Japan)*, **77**, 557, 1208 (1957).
[8] Bate-Smith, E. C., and Westall, R. G., *Biochim. Biophys. Acta*, **4**, 427 (1950). Bradfield, A. E., and Bate-Smith, E. C., *ibid.*, **4**, 441 (1950).
[9] Freudenberg, K., Karimullah and Steinbrunn, G., *Ann. Chem.*, **518**, 37 (1935).
[10] Freudenberg, K., and Roux, D. G., *Naturwiss.*, **41**, 450 (1954); *Ann. Chem.*, **613**, 56 (1958).
[11] Roux, D. G., *Chem. and Indust.*, 161 (1958). Freudenberg, K., and Weinges, K., *Ann. Chem.*, **613**, 61 (1958).

ANIMAL PHYSIOLOGY

Chlorothiazid in Diabetes Insipidus

Laragh and his co-workers[1] have demonstrated that chlorothiazid administered to normal subjects in the midst of a sustained water diuresis provokes a flow of urine of substantially higher concentration for a given rate of total osmolar output than urine formed by water-loaded subjects to whom meralluride is given. On the basis of this finding, they suggested that the site of action of chlorothiazid was in the distal portion of the nephron. Here, they postulated that the drug inhibited the production of 'free water' which normally results from selective re-absorption of sodium and accompanying anions. A drug acting to interfere with free-water formation would be of therapeutic value to the patient with diabetes insipidus, particularly the nephrogenic sort, if attendant losses of electrolyte in the urine were not unduly large, or, indeed, should they fail to occur.

Much more severe and sustained diabetes insipidus can be induced in the rat by electrolytic damage to the hypothalamus[2] than by the more usual technique of surgical removal of the posterior lobe of the pituitary gland. The technique consists of complete, or almost complete, destruction of the connexions in the anterior hypothalamus between the supra-optic nucleus and the pituitary stalk. The tracts concerned are difficult to identify in the rat[3] but are probably diffuse. The best combination of high survival-rate with severe diabetes insipidus is obtained by introducing stereotaxically two contiguous pairs of lesions at separate operations, allowing a recovery interval of 7–10 days. An initial pair of bilateral lesions gives rise to a mild diabetes insipidus characterized by water requirement ranging from just above normal (about 20 ml./250 gm. rat) to as much as 100 ml. a day when the adult animals consume quantitatively 20 gm. of diet 41 described by Bruce and Parkes[4]. The more severely affected animals are selected and respond to a second, similar operation by a marked increase in polyuria. On the same, 20 gm. diet allotment intakes of water following this procedure may exceed 400 ml. a day or almost twice the body-weight of the animal. The doubly operated animals fail to reduce the rate of flow of their urine in response to nicotine, hypertonic saline injection or 2-phenyl, 3-hydroxycinchoninic acid[5]. Sustained

water-loading does not provoke flows of urine significantly in excess of those seen during *ad libitum* drinking, and water restriction results in marked dehydration, food refusal and loss of body-weight.

Chlorothiazid has been administered to animals with this form of severe diabetes insipidus by admixture with the daily food ration. They respond within 24 hr. by reduction of intake of water by 50 per cent or more as indicated in Fig. 1. Urine osmolality rises from hypotonic levels to approach and, in some instances, to exceed by a small margin the tonicity of plasma. Urine *p*H is essentially unchanged, and the animals show no tendency to lose weight. The effect of the drug is sustained over long periods of time but disappears promptly on cessation of treatment. No influence on water turn-over is seen in similarly treated control animals. Nevertheless, in animals with submaximal diabetes insipidus, however mild, chlorothiazid causes the same proportionate reduction of water turn-over as it does in the more severe cases. Doses of 80 mgm./kgm. body-weight give a detectable effect; maximal response is seen at dose-levels of 300 mgm. a day and twice this dose has been reported to be well tolerated in normal rats for as long as six months[6].

The effect described for the rat is not species specific but has been reproduced in two human subjects, one with diabetes insipidus due to lack of vasopressin, the other with the nephrogenic type which is insensitive to the hormone. Within an hour of initial chlorothiazid administration there may occur an increase in urinary sodium, chloride and potassium excretion rates as well as a rise in urine osmolality. Urinary *p*H is not appreciably influenced. The solute diuresis is of brief duration; but the elevation in osmolality persists and within 6 hr. volume of urine begins to fall. The response of one patient in terms of the changes in urine volume and osmolality calculated on a 24-hr. basis is shown in Fig. 2. It will be noted also that though the dose requirement of the rat appears large, responses in the human are obtained at the same dose-levels as are employed when the drug is used as a diuretic. Clinical trials are being continued and will be reported elsewhere.

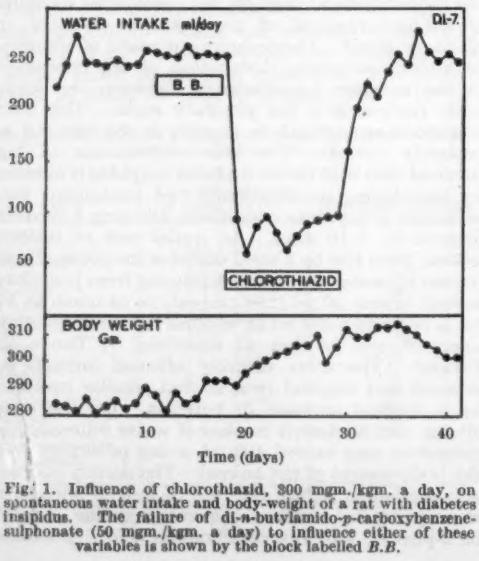


Fig. 1. Influence of chlorothiazid, 300 mgm./kgm. a day, on spontaneous water intake and body-weight of a rat with diabetes insipidus. The failure of di-*n*-butylamido-*p*-carboxybenzenesulphonate (50 mgm./kgm. a day) to influence either of these variables is shown by the block labelled *B.B.*

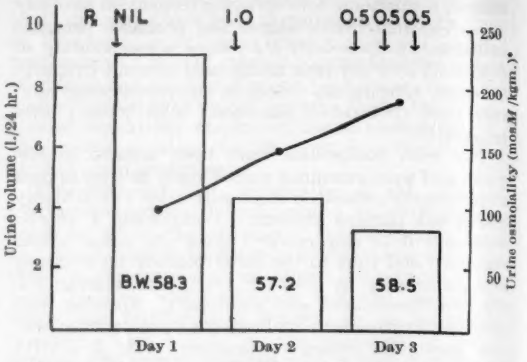


Fig. 2. Influence on urine volume (columns) and osmolality (interconnected points) of chlorothiazid in a woman with vasopressin insufficiency diabetes insipidus of three years duration. Day 1 represents a control 24-hr. period during which no treatment was given. A single 1-gm. dose was given at the start of day 2. On day 3, doses of 0·5 gm. were administered at 8-hourly intervals. Water to drink was allowed *ad lib.* and the diet was essentially constant throughout. Body-weights are given by the figures in the lower portions of the columns

Mrs. O. S. (46 yr.)

* This figure denotes total effective osmolal concentration of the urine in milliosmoles per kilogram of water found by determination of the urine's freezing point depression and division of the latter figure in deg. C. by the constant, 1·86.

The mechanism of action of the drug remains obscure. Treatment of the diabetic animals with heavy doses (100 mgm./kgm. a day) of the much more potent carbonic anhydrase inhibitor, acetazoleamide, results in no appreciable antidiuresis. Moreover, far more active inhibitors of tubular transport of *p*-amino-hippurate, phenol red and penicillin such as probenecid and its di-butyl analogue, which have been reported by Bachman[7] and Polster[8] to lessen the water turn-over in human diabetes insipidus, are similarly ineffective. Although the mechanism proposed by Laragh[1] may be invoked to explain the initial effect, its acceptance requires that one must postulate in addition a prompt, secondary adjustment leading to re-absorption of electrolytes at some site other than the point of free-water formation, since long-term therapy is well tolerated by the animals. Studies designed to clarify the mechanism by which the drug acts are in progress.

J. D. Crawford
G. C. Kennedy

Department of Experimental Medicine,
Cambridge.
Jan. 26.

[1] Laragh, J. H., Heinemann, H. O., and Demartini, F. E., *J. Amer. Med. Assoc.*, **168**, 145 (1958).
[2] Bruce, H. M., and Kennedy, G. C., *Proc. Roy. Soc.*, B, **138**, 528 (1951).
[3] Krieg, W. J. S., *J. Comp. Neurol.*, **55**, 19 (1932).
[4] Bruce, H. M., and Parkes, A. S., *J. Hyg.* (Camb.), **47**, 202 (1949).
[5] Dearborn, E. H., Lasagna, L., and Marshall, jun., E. K., *J. Pharmacol.*, **106**, 103 (1952).
[6] Beyer, K. H., *Ann. N.Y. Acad. Sci.*, **74**, 363 (1958).
[7] Bachman, H., *Munch. med. Wschr.*, **95**, 582 (1953).
[8] Polster, H., *Klin. Wschr.*, **35**, 1189 (1957).

Changes in the Group *A* Antigen in a Case of Leukæmia

Van Loghem and his colleagues[1] and Stratton *et al.*[2] have each reported a case in which a patient's group *A* antigen became weakened during the course of an illness. Salmon *et al.*[3] observed a similar case in which the red cells showed a 'double-cell population'. We have had the opportunity to observe a further

example of weakening of the *A* antigen, with double-cell population, and, in addition, a partial reversion towards normal during a temporary clinical remission.

A male patient aged nineteen years was admitted to hospital because of acute monoblastic leukæmia. In routine blood grouping tests for a transfusion his red cells were very weakly agglutinated by the anti-*A* grouping serum. Anti-*B* agglutinins were present in his serum in normal titre. A differential agglutination test showed that approximately 2 per cent of the cells were agglutinated by potent anti-*A* sera; but the remainder, although inagglutinable, absorbed anti-*A* to the same extent as A_2 cells. This anti-*A* could readily be eluted by the heat-method. 3 days later, the red cells in a fresh sample were no longer agglutinable, even by selected group *O* 'immune' anti-*A* sera, but continued to absorb anti-*A*. At this time, the total white cell count was 118,000 per cu. mm., of which approximately 90,000 were 'blast' cells.

After treatment for 8 weeks with 6-mercaptopurine and prednisone, the total leucocyte count had fallen to 2,300 per cu. mm., a very occasional blast cell only being present in the peripheral blood and the bone marrow. To our surprise, approximately 35 per cent of red cells were now agglutinated by anti-*A* sera (group *B*). There was no agglutination by Dolichos anti-A_1, the agglutinable cells appearing to behave, therefore, as normal A_2 cells. The unagglutinated cells, separated by differential agglutination, continued to absorb anti-*A*.

The partial reversion towards normal which accompanied the hæmatological remission was also paralleled by a clinical remission. The 6-mercaptopurine was discontinued and 7 weeks later, when the total leucocyte count had risen to 7,900 per cu. mm. (blast cells, 790), the percentage of agglutinable *A* cells had fallen to 20 per cent. The clinical remission terminated abruptly 4 weeks later and just before death, with a blast cell count of 23,600 per cu. mm. (total leucocytes 62,000); 8 per cent only of red cells in peripheral blood and marrow were now agglutinable.

During the period of observation, there was no change in the patient's anti-*B* agglutinins and no irregular anti-*A* antibodies could be demonstrated *in vitro*. *In vivo*, however, 1 ml. of group A_1 red cells labelled with chromium-51 survived for a much shorter time than similarly labelled group *O* cells. When transfusion was necessary, therefore, group *O* packed cells were selected in preference to group *A*. Unfortunately, circumstances prevented a repeat injection of labelled group *A* and *O* cells, and we were unable to establish definitely, therefore, that the blood-group change was accompanied by an unexpected intolerance to small amounts of group A_1 blood. No group *A* substance was found in the serum or saliva, even using a group *O* anti-*A* serum which agglutinated A_x cells. Tests of the two types of red cells present, after separation, for other blood group antigens (*M*,*N*,*S*, *P*, *H*, Le^a, *C*,*D*,*E*,*c*,*e*, Jk^a, *Kell*, Fy^a) showed no differences, except that, whereas both types of red cells were agglutinated by anti-*H* (*Ulex*) and anti-Le^a, the cells inagglutinable by anti-*A* reacted considerably more strongly with the anti-*H* but slightly less strongly with the anti-Le^a than did those agglutinable by anti-*A*.

It is interesting to note that in this case, as in those reported by Van Loghem and his colleagues, and by Stratton *et al.*, the red cells were Le^a-positive and the patient was a non-secretor of *A* and *H* substance. These three antigens are chemically related, and in the four cases now on record in which the *A* antigen has been modified by disease, the patient's underlying illness was leukæmia. The case reported by Stratton *et al.* presented as a hypoplastic anæmia, but terminated as a leukæmia (Stratton, F., personal communication, 1959). Our case was established as a monocytic leukæmia and remained as such throughout its course. No explanation can yet be given concerning the mechanism of the changes in blood group, though Haddow's[4] hypothesis of genetic and enzymatic deletion in neoplasias, including leukæmia, by physical, chemical or viral agents might provide an explanation for a similar action on genes governing the formation of the *A*, *H* and Le^a antigens.

The patient's blood group was not known prior to his illness. His mother is A_1 and his father *O*. Family studies have failed to demonstrate the mother's genotype; but the patient's only brother and his three maternal aunts and uncles are A_1 or A_1B. By inference, therefore, it is more likely that the patient's group was A_1 rather than A_2. It is most unlikely that it was A_x, since the agglutinable cell population behaved as normal A_2 cells.

We wish to thank Dr. G. Mather for the opportunity to investigate this patient, and Drs. N. F. W. Brueton and F. Freundlich for their assistance in the investigations.

E. R. Gold
Geoffrey H. Tovey
South-West Regional Transfusion Centre.
W. E. Benney
F. J. W. Lewis
Department of Pathology,
Southmead Hospital,
Bristol. Jan. 6.

[1] Loghem, J. J. van, Dorfmeier, H., and Hart, M. van der, *Vox Sang.*, **2**, 16 (1957).
[2] Stratton, F., Renton, P. H., and Hancock, J. A., *Nature*, **181**, 62 (1958).
[3] Salmon, C., Dreyfus, B., and André, R., *Le Sang*, **13**, 148 (1958).
[4] Haddow, A., *Brit. Med. Bull.*, **14**, 73 (1958).

Absorption of Radioiodine through the Bladder-Wall in the Rabbit

Numerous studies have been made of the absorption of a variety of substances through the bladder-wall in frogs, rabbits, canines and humans[1–8]. We report below a study of some factors influencing the absorption of iodide ions in rabbits.

Male rabbits weighing 2–3·5 kgm. were used, and experiments were carried out under urethane anæsthesia. The rabbits were catheterized with Nélaton catheters (diam. 12–13 Charrière), and urine samples were shown to be free of hæmoglobin. After irrigation of the bladder with isotonic saline, radioiodine or a compound of it was introduced into the bladder. Blood samples were collected after 0, 20, 40, 60 and 80 min. from the marginal ear vein. Beta-activity of the samples was measured with a Geiger–Müller counter.

(1) In 3 animals 10–20 ml. isotonic saline containing 0·36–2·0 mc. of sodium iodide labelled with iodine-131 was left in the bladder for 45 min. After 24 hr. the thyroid glands showed activities of 7–23 μc. Approximate determinations of gland activities were carried out on a phantom with the help of a scintillation counter. The results demonstrate absorption of radioiodine through the bladder-wall.

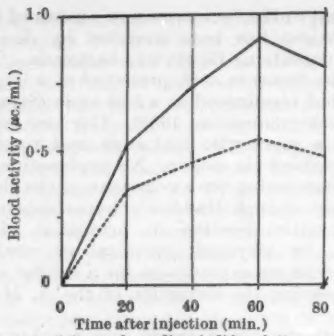


Fig. 1. ———, 1·2 osmolar sodium iodide solution; - - - -, 30 milliosmolar sodium iodide solution

(2) In 4 rabbits 5 ml. isotonic saline containing 20 mgm. radioiodinated human serum albumin with an activity of 700 μc. was introduced into the bladder and left for 60 min. In two animals 1 mgm. hyaluronidase was added to the solution. Whole samples were rendered free from protein with 15 per cent trichloracetic acid. Measurements made on the filtrate and on the precipitate did not show significantly higher values than in group 1. These results indicate that molecules of the size of serum albumin are relatively unabsorbed through the bladder-wall.

(3) In 3 rabbits 1 mgm. adrenaline was introduced along with 5 ml. isotonic saline containing 1 mc. radioiodine. No significant differences were found in comparison with 3 controls. This showed that the addition of adrenaline did not alter in any significant way the absorption of radioiodine under the experimental conditions described.

(4) In 9 rabbits 5 ml. of a 30 milliosmolar non-radioactive sodium iodide solution was used, and in a further 9 animals a 1·2 osmolar sodium iodide solution was applied, 1 mc. of labelled sodium iodide being added to each solution. The activities of blood samples were higher in all animals receiving the hypertonic solution. Mean activity curves of both groups are shown in Fig. 1. The results show a dependence of absorption on concentration gradient.

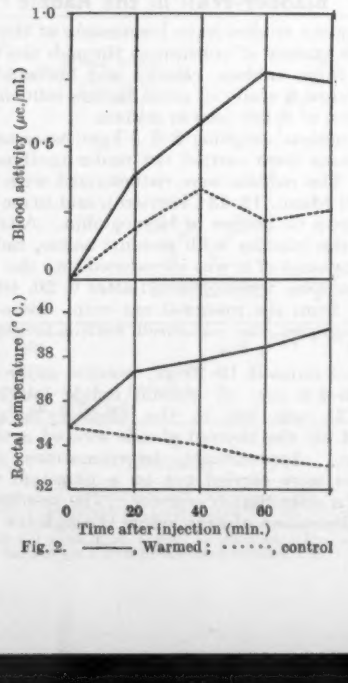


Fig. 2. ———, Warmed; ·····, control

(5) In 8 rabbits 5 ml. of 0·3 osmolar sodium iodide with activity of 1 mc. was introduced into the bladder. In 5 animals the lower part of the body was heated by short-wave diathermy or by infra-red rays. The average rise of rectal temperature amounted to 4° C. after 60 min. Curves of mean blood activity and rectal temperature of both groups are shown in Fig. 2. These findings demonstrate a dependence of absorption on the rectal temperature and therefore on the rate of blood supply to the bladder-wall.

We conclude that significant re-absorption of urinary iodide occurs through the bladder-wall and suggest that local bladder conditions should be taken into account in quantitative physiological studies with this ion.

Oskar Andrysek
Ota Schück

Institute for Medical Physics and
First Medical Clinic,
Charles University, Prague.

[1] Frey, F., *Beitr. klin. Chir.*, **155**, 577 (1932).
[2] Lundberg, S., *Acta chir. Scand.*, **64**, 551 (1929).
[3] Maluf, N. S. R., *J. Urol.*, **69**, 396 (1953).
[4] Maluf, N. S. R., *J. Urol.*, **5**, 830 (1955).
[5] Marucci, H. D., *Surg. Gyn. Obstetr.*, **101**, 285 (1955).
[6] Sawyer, W. H., and Schigsgall, R. M., *Amer. J. Physiol.*, **187**, 312 (1956).
[7] Schär, W., *Z. urol. Chir.*, **44**, 183 (1928).
[8] Szendrői, Z., Magasi, P., and Mátyus, E., *Z. urol.*, **51**, 99 (1958).

Disturbance in the Pattern of Serum Proteins in Experimental Atherosclerosis and its Prevention

It has recently been reported by two of us[1,2] that various kinds of experimental atherosclerosis, indicated by great increase in the total cholesterol/lipid phosphorus ratio in the blood and tissues of animals, can be prevented by hydrolysed glucose–*cyclo*acetoacetate, a product formed by condensing glucose with acetoacetate. It was shown by Van Dommeleu and Schutt[3] that albumin fraction is low and γ-globulin is high in diabetic coma, and Klinger[4] observed that when diabetes is accompanied with severe hypertension, there is a further decrease of albumin and a sharp increase of γ-globulin. As according to Dawber *et al.*[5] hypertension is usually associated with the incidence of atherosclerosis, attempts were made to study the protein pattern in the serum of saturated fat-induced atherosclerotic animals and in those prevented by essential fatty acids, inositol, vitamin B_{12} and glucose–*cyclo*acetoacetate (hydrolysed).

Thirty-five male albino rabbits weighing on an average 1·2 kgm. were divided into seven equal groups and caged individually. The animals of group 1 were fed with a laboratory stock diet consisting of casein 20 gm., sucrose 30 gm., wheat flour 39 gm. groundnut oil 6 gm., Hawk Oser salt mixture 5 gm. and all the vitamins of B complex group and vitamins A and D in requisite quantities. The animals of all the remaining groups were given saturated fat (20 per cent of the diet) in place of groundnut oil. The animals of group II were taken as control while those of groups III and VI were injected with a daily dose of 300 mgm./kgm. and 15 μgm./kgm. body-weight of glucose–*cyclo*acetoacetate (hydrolysed) and vitamin B_{12} ('Macrabine', Glaxo) respectively, and those of groups IV, V and VII were given 1 gm. of linoleic, linolenic acid and inositol respectively along with the saturated fat diet.

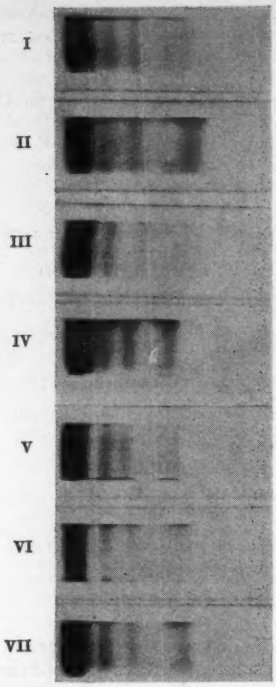


Fig. 1. Agar electrophoresis patterns of serum proteins of normal, saturated fat-induced atherosclerotic and treated animals. (I) Normal; (II) saturated fat-induced; (III) kept on saturated fat and injected with glucose-*cyclo*acetoacetate (hydrolysed); (IV) linoleic acid supplemented; (V) linolenic acid supplemented; (VI) kept on saturated fat and vitamin B_{12} injected; (VII) inositol supplemented

The experiment was carried on for a period of 12 weeks. The blood samples were drawn from the marginal ear veins of the rabbits, and the serum obtained by the usual method was used for electrophoretic studies.

The agar electrophoresis technique developed by Giri[4] was employed for the separation and staining of serum proteins, amidoschwarz 10*B* in 100 ml. of solvent mixture of the composition methanol/acetic acid/water (40 : 10 : 50) being used for staining.

Albumin, α-, β- and γ-globulins in the serum were found to be clearly separated on the agar plate. Photographs of the serum patterns of the rabbits of normal and experimental groups are shown in Fig. 1. The electrophoresis of serum samples was run under exactly identical conditions. From pattern II, it is evident that the γ-globulin fraction of the rabbits kept on high saturated fat diet increased appreciably with a simultaneous decrease in the albumin fraction as compared to pattern I of normal rabbits. On the other hand, in the patterns IV (linoleic acid supplemented), V (linolenic acid supplemented) and VII (inositol supplemented), it has been observed that the γ-globulin fractions, although found to be less than that in pattern II (kept on saturated fat diet), the amount was not as low as in normal animals. It is further observed from pattern IV that the effect of linoleic acid in suppressing the rise of γ-globulin fraction was not so pronounced as in the case of linolenic acid and inositol (patterns V and VII respectively). The serum pattern of animals injected with vitamin B_{12} (pattern VI) was found to show a greater decrease in γ-globulin fraction and increase in albumin fraction than those of patterns IV, V and VII; but still the pattern was not normal. However, the serum protein pattern III of rabbits injected with hydrolysed glucose-*cyclo*acetoacetate is found to be very similar to the normal pattern I.

From the above findings, the γ-globulin fraction has been increased in the animals with atherosclerosis induced by a saturated fat diet that could be corrected by glucose-*cyclo*acetoacetate (hydrolysed), which has already been shown to contain 1 : 2 dienol glucose[7] and to cause prevention of experimental diabetes of various kinds[8-10]. It has recently been suggested by Beveridge *et al.*[11] that the serum cholesterol lowering effect of corn oil is due to something besides the unsaturated fatty acid glycerides of the corn oil, and Grande *et al.*[12] have shown that such a factor (*X*) is present in the unsaponifiable fraction of corn oil. It is quite possible that such *X* factor may be in some way or the other related to glucose-*cyclo*acetoacetate or its hydrolysed product.

M. C. Nath
A. Saikia
B. I. Uppin

Department of Biochemistry,
University, Nagpur.
Nov. 1.

[1] Nath, M. C., and Saikia, A., *Ind. J. Med. Res.*, **46**, 579 (1958).
[2] Nath, M. C., and Saikia, A., *Arch. Biochem. Biophys.*, **79**, 216 (1959).
[3] Van Dommelen, C. K. V., and Schutt, M. J., *Ned. Tijdschr. Geneaskunde*, **98**, IV, 2878 (1954).
[4] Klinger, R., *Arch. Sci. Med.*, **95**, 141 (1953).
[5] Dawber, T. R., Moore, F. E., and Mann, G. V., *Amer. J. Pub. Health*, **47**, 5 (1957).
[6] Giri, K. V., *Naturwiss.*, **43**, 232 (1956).
[7] Nath, M. C., and Bhattathiry, E. P. M., *Nature*, **178**, 1233 (1956).
[8] Nath, M. C., and Sahu, V. K., *Metabolism*, **5**, 3 (1956).
[9] Nath, M. C., and Behki, R. M., *Metabolism*, **6**, 127 (1957).
[10] Nath, M. C., and Behki, R. M., *Arch. Biochem. Biophys.*, **73**, 65 (1958).
[11] Beveridge, J. M. R., Connell, W. F., and Mayer, G. C., *Fed. Proc.*, **16**, 11 (1957).
[12] Grande, F., Anderson, J. T., and Keys, A., *Proc. Soc. Exp. Biol. and Med.*, **98**, 436 (1958).

Study of Adenovirus Antigens by Immunoelectrophoresis

Multiplication of adenoviruses in susceptible cells is accompanied by the formation of antigenic materials which can be distinguished from virus particles. These materials have been detected by different serological techniques including complement fixation[1,2], sensitized red-cell agglutination[3], conglutinating complement adsorption[4] and gel diffusion precipitation[5]. Part of the non-virus material is responsible for the early cytopathic[6] and cell-detaching[7] properties which are abolished by incubation with trypsin or by addition of homologous antiserum, a result suggesting that they are mediated by an antigenically specific protein.

Observations with the gel diffusion precipitation technique have shown at least three antigens in partially purified preparations of adenovirus type 5. The conditions under which precipitation occurs make it clear that these antigens are considerably smaller than intact virus particles[8]. Results of experiments in which the three precipitating antigens were separated by electrophoresis are presented in this communication.

The virus material used consisted of the prototype strain of adenovirus type 5 propagated in HeLa cells

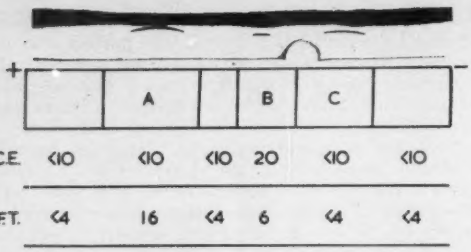


Fig. 1. Immunoelectrophoresis of adenovirus type 5 antigen tested against homologous antiserum. Top, photographic print of precipitation lines; bottom, early cytopathic effect (E.C.E.) and complement-fixing titres (C.F.T.) of extracts from agar sections

and partially purified by the method of Gessler *et al.*[9] using the fluorocarbon compound 'Arcton 63' as previously described[10]. Adenovirus type 5 antiserum was obtained from a rabbit with a latent infection[11]. The serum reacted strongly with the virus antigen in complement fixation and gel diffusion precipitation tests, while no reactions with normal HeLa cell antigens could be demonstrated by either technique.

Immunoelectrophoresis[12] was performed in a gel[8] composed of 2 per cent washed agar in borate–phosphate buffer ($\mu = 0{\cdot}05$ *p*H 8·5)[12]. The same buffer was present in the electrode baths and on the lint connecting strips. Electrophoresis of 0·1-ml. samples of the antigen was conducted at room temperature with a current of 20 m.amp. for 7–8 hr. Antiserum placed in pre-formed side channels was allowed to react with the antigenic material at 4° C. in a moist chamber. After 5–6 days the gel was washed in saline, dried, stained with naphthalene black and made into a permanent preparation.

Three antigens with different electrophoretic mobilities could be demonstrated (Fig. 1). These will be designated antigens *A*, *B* and *C*. In order to characterize the antigens they were eluted from the agar. After electrophoresis the agar was cut in half by an incision through the origin along the plane of migration. One half was treated with antiserum to show the position of the antigenic components. The other half was cut into sections according to the expected position of the antigens. Each section was cut into small pieces and suspended in 1 ml. of normal saline at 4° C. for 4 days. The saline extracts were then tested for complement fixation against an optimal dilution of homologous antiserum and for early cytopathic action on HeLa cells, the results being read after overnight incubation of the cultures[6]. Complement-fixing activity was detected in fractions corresponding to antigens *A* and *B*. The titres obtained were relatively low, suggesting poor recovery, which may explain the negative result given by the third antigenic component.

Early cytopathic activity was associated with antigen *B* only, although the complement-fixing activity of this component was less than that of component *A*. Further evidence that antigen *B* is responsible for the early cytopathic action is provided by the effects of trypsin treatment of the virus material. This abolishes the early cytopathic effect[6] and brings about only a slight reduction in complement-fixing titre[8]. When immunoelectrophoresis is carried out on trypsin-treated material, components *A* and *C* are unaffected but component *B* is no longer demonstrable.

The relationship of these antigenic components to non-viral crystalline material appearing in ultra-thin sections of adenovirus-infected cells[14] remains to be established.

H. G. Pereira
A. C. Allison
C. P. Farthing

National Institute for Medical Research,
Mill Hill, London, N.W.7.
Jan. 6.

[1] Huebner, R. J., Rowe, W. P., Ward, T. G., Parrott, R. H., and Bell, J. A., *New England J. Med.*, **251**, 1007 (1954).
[2] Hilleman, M. R., Werner, J. H., and Stewart, M. T., *Proc. Soc. Exp. Biol., N.Y.*, **90**, 555 (1955).
[3] Friedman, M., and Bennett, C. R., *Proc. Soc. Exp. Biol., N.Y.*, **97**, 712 (1957).
[4] Prier, J. E., and LeBeau, R. W., *J. Lab. Clin. Med.*, **51**, 495 (1958).
[5] Pereira, M. S., Pereira, H. G., and Allison, A. C., *Lancet* (in the press).
[6] Pereira, H. G., *Virology*, **6**, 601 (1958).
[7] Rowe, W. P., Hartley, J. W., Roizman, B., and Levi, H. B., *J. Exp. Med.*, **108**, 713 (1958).
[8] Allison, A. C., and Pereira, H. G. (to be published).
[9] Gessler, A. E., Bender, C. E., and Parkinson, M. C., *Trans. N.Y. Acad. Sci.*, **18**, 701 (1956).
[10] Pereira, H. G., and Valentine, R. C., *J. Gen. Microbiol.*, **19**, 178 (1958).
[11] Pereira, H. G., and Kelly, B., *Nature*, **180**, 615 (1957).
[12] Grabar, P., and Williams, C. A., *Biochim. Biophys. Acta*, **10**, 193 (1953).
[13] Porath, J., *Biochim. Biophys. Acta*, **13**, 175 (1954).
[14] Morgan, C., Goodman, G. C., Rose, H. M., Howe, C., and Huang, J. S., *J. Biophys. Biochem. Cytol.*, **3**, 505 (1957).

Effect of Tranquillizing Agents on the Resistance of Rats to Histamine Stress

In view of the long-continued interest in the relationship of histamine to metabolic processes and disorders, most particularly allergy and psychosis, the present investigation sought to explore the effects of prolonged administration of various tranquillizers on response in the rat to histamine, including effects on such variables as histamine *LD*50, mortality and alterations in body-weight.

Male albino Wistar rats (80–90 per test group), averaging 100 gm., were injected subcutaneously with 1 ml. aqueous preparations of different tranquillizers daily for a two-week period. Control rats received 1 ml. daily injections of distilled water. On the fifteenth day, test and control groups were injected intraperitoneally with various amounts of histamine phosphate. The challenging doses ranged from 300 to 1,100 mgm./kgm. body-weight. Finney's[1] method of probit analysis was used for calculating the *LD*50 values and dose–response lines.

Table 1 presents the various tranquillizing agents studied, their concentrations and the histamine *LD*50, body-weight and mortality-rate results. The study indicated that hydroxyzine hydrochloride, reserpine and promazine hydrochloride are effective in preventing death from histamine shock, whereas azacyclonal hydrochloride has an intermediate effect and chlorpromazine hydrochloride a negligible influence.

Statistical analyses of the results for histamine *LD*50 revealed that hydroxyzine hydrochloride and promazine hydrochloride produce significant increases in resistance of the rat to histamine and the increase produced by reserpine approached statistical significance at the 0·05 confidence-level. Additional calculations revealed that none of the differences between the slopes of the various test and control dose–response lines were statistically significant.

As is apparent in Table 1, all tranquillizing agents studied caused significant declines in the terminal

Table 1. Effect of Tranquillizing Agents on Mortality-Rates, Body-Weight and *LD*50 Values

Agent	Concentration (mgm./ml.)	Tranquillizer mortality (per cent)	Terminal body-weight	Difference between test and control (per cent)	*P* value	*LD*50 (mgm./kgm.)	Difference between test and control (per cent)	*P* value
Control	1 ml. distilled water	0	168·7±1·3			599·3±40·2		
Chlorpromazine hydrochloride	0·1	3·3	151·3±2·6	−10·3	< 0·001*	606·4±48·1	± 1·2	0·88
Azacyclonal hydrochloride	1·0	0	159·9±2·2	−5·2	0·05*	665·3±51·0	±11·0	0·20
Promazine hydrochloride	0·1	12·5*	152·8±0·7	−9·4	< 0·01*	700·4±39·8	±16·9	0·03*
Reserpine	0·007	26·7*	145·7±2·9	−13·6	< 0·001*	699·3±53·3	±16·7	0·08
Hydroxyzine hydrochloride	0·07	18·9*	135·7±3·1	−19·6	< 0·001*	816·6±35·5	±36·3	0·001*

* Difference between test group and control is significant.

body-weights of the treated rats in the dosages and time patterning of these experiments. Prior to histamine administration, all tranquillizers except azacyclonal hydrochloride and chlorpromazine hydrochloride caused significant increases in the mortality-rates of the rats during the two-week period. A preliminary study with reserpine concentrations of 0·1 mgm./ml. had to be discontinued after 7 days due to the excessive mortality-rate. Although Gaunt *et al.*[2] do not indicate the mortality-rates caused by various reserpine concentrations, they do state: "In work with normal rats, we found that 10 mcgm./100 gm./day of reserpine was not well tolerated when given for prolonged periods of time. It interfered with growth, appetite, etc., and we considered it unsuitable for chronic use".

In conclusion, hydroxyzine hydrochloride, reserpine and promazine hydrochloride when administered for two weeks caused marked increases in resistance to histamine as measured by histamine *LD*50. Except for azacyclonal hydrochloride, increase in resistance to histamine was associated with loss in body-weight and increase in pre-histamine administration mortality.

Arthur M. Sackler
A. S. Weltman
Raymond R. Sackler

Laboratories for Therapeutic Research,
Research Institute of the Brooklyn College of Pharmacy,
Long Island University, Brooklyn, New York, and
The van Ophuijsen Center, New York.

[1] Finney, D. J., "Probit Analysis", 2nd ed. (Cambridge Univ. Press, Cambridge, 1952).
[2] Gaunt, R., Renzi, A. A., Antonchak, N., Miller, G. J., and Gilman, M., *Ann. New York Acad. Sci.*, **59**, 22 (1954).

Slow Contraction of Smooth Muscle produced by Human Plasma

Human blood plasma or serum produces a delayed, slow contraction of the isolated ileum of the guinea pig. This effect is best observed with dialysed plasma, since dialysis eliminates the quick-contracting agents[1]. Recently, Gabr[2] described the isolation from the *G*.2 fraction of human plasma[3] of a fatty acid which has an effect similar to that of plasma on the isolated ileum of the guinea pig.

Preliminary experiments carried out on processed human plasma for transfusion purposes showed that storage at room temperature of liquid plasma[4] changes the character and potency of its contracting effect on the isolated ileum. It has also been observed that processing of the plasma with kaolin[5] and pooling of the plasma derived from stored banked blood produce similar changes. These observations may be summarized as follows:

(1) Storage of liquid plasma at room temperature under sterile conditions for six months decreases its toxicity for the isolated ileum of the guinea pig. The muscle contraction starts more slowly, and the recovery of the smooth muscle takes a longer time after repeated washings of the preparation with the test fluid (Tyrode solution).

(2) Processing of human plasma with kaolin considerably decreases its effect on the isolated ileum. Like normal plasma, kaolin-processed plasma becomes less toxic when stored for six months at room temperature.

(3) Pooled human plasma is less active on the isolated ileum than single-donor plasma. This effect seems to depend on the size of the plasma pool. Plasma pools derived from ten bottles of banked blood were found to be less active on the isolated ileum than plasma pools derived from seven bottles of banked blood. Again, the latter pools were less active than smaller pools derived from three blood bottles. In the case of big plasma pools, the onset of muscle contraction was much slower, and the summit of contraction often declined a few seconds after.

(4) No relation could be found between the toxicity of pooled plasma and the group types of the blood bottles from which the plasma was separated.

(5) The effect of pooled plasma on the isolated ileum of the guinea pig decreases slightly after standing for one week at room temperature prior to freeze-drying.

Yousry Gabr
Raga H. Aly

Blood Products Unit,
Serum and Vaccine Institute,
Agouza, Cairo.
Jan. 14.

[1] Schachter, M., *J. Physiol.*, **129**, Proc. 30 (1955).
[2] Gabr, Y., *Brit. J. Pharm. Chem.*, **11**, 93 (1956).
[3] Kekwick, R. A., and Mackay, M. E., Medical Research Council Special Rep. Ser. No. 286 (H.M.S.O., London, 1954).
[4] Allen, J. G., Sykes, C., Enerson, D. M., Moulder, P. V., Elghammer, R. M., Grossman, B. J., McKeen, C. L., and Galluzzi, N., *J. Amer. Med. Assoc.*, **144**, 1069 (1950).
[5] Maizels, M., *Lancet*, ii, 205 (1944).

Barbiturate Nystagmus and the Mechanisms of Visual Fixation

When a human subject follows a moving object with his eyes, they perform movements of two types[1,2]. There are smooth pursuing movements and rapid jerky changes of position known as saccades. Fig. 1*a* is a record of the position of an eye which is fixating a small spot of light in an otherwise totally

dark room. Up to time $t = 0$ this spot of light has remained stationary in front of the subject. At time $t = 0$ it begins to move horizontally with a uniform velocity of 3 deg./sec. It can be seen that the eye remains stationary for about 150 msec., and then begins to move smoothly in pursuit of the spot. When about 300 msec. has elapsed since the spot began to move, the eye makes a saccadic movement at the end of which it is again looking directly at the spot. Thereafter the eye continues to move with the same velocity as the spot, and fixation is as good as it is when the spot is not moving.

It is known[2] that moderate doses of barbiturates produce a nystagmus in normal subjects when the eyes are deviated to look at an object which is displaced from the forward direction. The slow phase of the nystagmus is towards the central position and the quick phase is towards the object. Fixation on an object directly in front of the subject is disorganized and random movements of the eyes occur.

It is of interest to know how barbiturates will affect the way in which the eyes pursue a moving object. Fig. 1*b* shows a record taken on the same occasion as Fig. 1*a* after the intravenous administration of 100 mgm. of 'Pentothal' in the course of 8 min. It can be seen that the ability of the eye to make smooth pursuing movements is abolished and it proceeds in a succession of jerks each one refixating the escaping spot.

A few further observations about visual tracking will permit an explanation of the effects of barbiturates. Smooth eye-movements are caused by the movement of the spot of light and not by its position. Fig. 2 shows the response of the eye to a spot which, initially stationary and straight ahead, moves instantly to the left and then proceeds with uniform velocity towards the right. The eye starts to move smoothly to the right although this is away from the position of the spot. The mechanism for smooth movements is aiming at achieving a stationary image on the retina irrespective of error in the position of fixation. Such an error is then corrected by a jerk

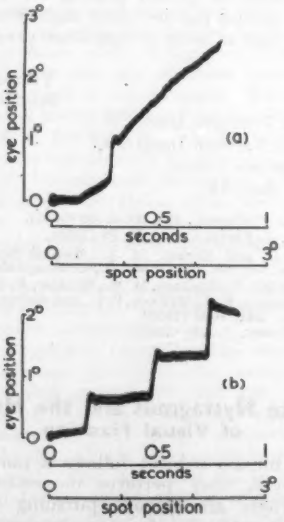


Fig. 1. Records of the eye-movements caused by watching a spot moving with constant velocity (*a*) before and (*b*) after the administration of 100 mgm. 'Pentothal' intravenously

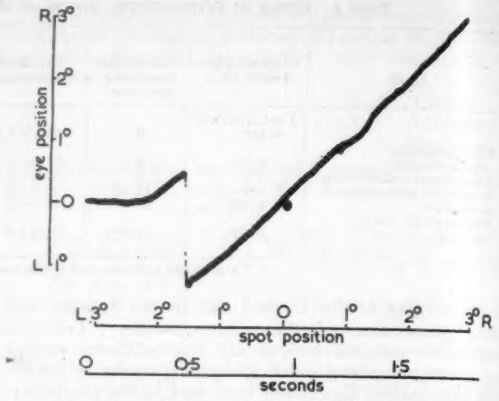


Fig. 2. Record of the eye-movement caused by watching a spot which is suddenly given a change of position in one direction and a velocity in the opposite direction

provided that it exceeds about 0·1 deg. and some 200 msec. has elapsed since the previous jerk.

It is probable that no other mechanism is involved in fixating a stationary spot. When this is straight ahead, the eyes will be held stationary by the smooth mechanism except for very slow drifts in either direction[4] at velocities which are too slow for the eye to detect. When a sufficiently large error in position accumulates it will be corrected by a jerk. When the fixation spot is to one side the same things happen except that the drifts tend to be towards the centre[4].

Barbiturates abolish the smooth mechanism. Therefore, on forward fixation, spontaneous smooth movements of the eyes will not be prevented, and apparently random movements will occur with many refixation jerks. On deviated fixation these uncorrected smooth movements will be towards the centre with large outward refixation jerks at a rate up to 5/sec., this being the barbiturate nystagmus.

A description of the method used for recording eye movements and further details will be published elsewhere.

This work was assisted by a grant from the Bethlem Royal and Maudsley Hospitals Research Fund which is gratefully acknowledged.

C. Rashbass

Institute of Psychiatry,
Maudsley Hospital,
Denmark Hill,
London, S.E.5.

[1] Dodge, R., Travis, R. C., and Fox, J. C., *Arch. Neurol. Psychiat.*, **24**, 21 (1930).
[2] Westheimer, G., *Arch. Ophthal.*, **52**, 932 (1954).
[3] Bergman, P. S., Nathanson, M., and Bender, M. B., *Arch. Neurol. Psychiat.*, **67**, 357 (1952).
[4] Cornsweet, T. N., *J. Opt. Soc. Amer.*, **46**, 987 (1956).

Inhibition of Sensitiveness to Nicotine of Rabbit Aorta by Reserpine, Hexamethonium, Ethyl Flavone-7-Oxyacetate and Other Compounds

Burn and Rand[1] demonstrated that some spastic effects of nicotine on aortic strips can be abolished by a prophylactic treatment with reserpine. The present investigation was conducted in order to study

Table 1. Substances which Provoke a Submaximal Contraction of the Aortic Chain

Substance	Concentration (μgm./ml.)
Adrenaline (on aortic chains of normal rabbits)	0·4–0·8
Adrenaline (on aortic chains of reserpine-treated rabbits)	0·2–0·4
Acetylcholine chloride	2–10
Histamine dihydrochloride	0·25
5-Hydroxytryptamine	1
Barium chloride	>150
Nicotine sulphate (on the fresh aortic chain)	~150
Nicotine sulphate (on the aortic chain sensitized by adrenaline)	2·5–15

how reserpine or other drugs are able to prevent the spastic activity of nicotine on this blood vessel.

The experiments were carried out on chains obtained by binding together about eighteen 2-mm. wide rings cut from the thoracic aorta of a rabbit. The chains were suspended in Ringer–Locke solution, aerated with oxygen at 37° C., and the contractions recorded. The active concentrations of nicotine and some other substances, able to cause a contraction of the aortic chain, are reported in Table 1. Nicotine itself, scarcely active on the fresh preparation, becomes very active after 2–4 contractions induced by adrenaline, histamine or acetylcholine.

Up to a concentration of 200 μgm./ml., nicotine did not cause any contraction if 0·5 mgm./kgm. reserpine had been daily administered subcutaneously, in the four days before the experiment, to the rabbits the aortic chains of which were used. This treatment did not affect the spastic activities of the other agents listed in Table 1.

On the other hand, reserpine added directly to the perfusion fluid up to a concentration of 3 μgm./ml. did not affect the sensitiveness of chains to nicotine; with higher concentrations an interference due to solvents was observed.

In order to investigate the mechanism of the action of nicotine, the activities of some antagonistic drugs were tested against the contractions induced by nicotine (Table 2) and some other drugs (Table 3).

Table 2. Inhibition of Nicotine Contractions of the Aortic Chain

Substance	*ED*50 (μgm./ml.)*
Atropine sulphate	5
Dihydroergotamine	16
Hexamethonium	0·25
Pyrilamine hydrochloride	2·5
Reserpine	>3†
Papaverine hydrochloride	40
Ethyl flavone-7-oxyacetate	40
Aminophylline	160

* Concentration that inhibited by 50 per cent the contractions of the aortic chain due to 5 μgm./ml. of nicotine sulphate.

† With higher concentrations an inhibition due to the solvents was observed.

Table 3. Inhibitor Activity against some Stimulating Agents

Stimulating agent	Inhibitor	*ED*50 of the inhibitor (μgm./ml.)
Acetylcholine chloride, 5 μgm./ml.	Atropine sulphate	0·02
Adrenaline, 0·5 μgm./ml.	Dihydroergotamine	15
Adrenaline, 0·5 μgm./ml.	Hexamethonium	>150
Histamine dihydrochloride, 0·25 μgm./ml.	Pyrilamine hydrochloride	0·001

Since atropine and pyrilamine are much more effective in counteracting acetylcholine and histamine-induced spasm than nicotine contractions, the latter probably are not due to an acetylcholine or histamine liberation. On the other hand, dihydroergotamine antagonizes adrenaline-induced contractions at the same concentration as nicotine-induced contractions, and therefore it is possible that arterial nicotinic spasm is mediated through adrenaline or adrenaline-like substances. This conclusion is also supported by the characteristics of the activity of reserpine, which is able to inhibit the sensitivity to nicotine only if administered to the animals for some days, while the same drug is inactive if put directly in contact with the aortic chain. Probably, when chronically administered, reserpine depletes the aorta[1] as well as some other organs[2] of catecholamines and therefore nicotine cannot liberate adrenaline-like substances in the aortic chains of animals treated with reserpine.

The high inhibitory activity of hexamethonium against nicotine contractions could be easily explained if aortic sympathetic ganglia were stimulated by nicotine and blocked by hexamethonium. Since aortic sympathetic ganglia have not yet been demonstrated, an antagonistic effect of hexamethonium on a direct liberation of sympathetic substances from the cells due to nicotine may be possible.

The inhibiting mechanism of papaverine and ethyl flavone-7-oxyacetate, two powerful spasmolytics and coronary dilators, is probably a myotropic one.

As a result of this work, reserpine therapy in vascular diseases due to smoking is suggested. A combined treatment with some other nicotine contraction inhibitors, particularly with ethyl flavone-7-oxyacetate, might also be of some value, because this drug, compared with the others listed in Table 2, has a very low general toxicity.

I. Setnikar
M. Ravasi

Research Department,
Recordati Laboratorio Farmacologico S.p.A.,
Milan.
Jan. 7.

[1] Burn, J. H., and Rand, M. J., *Brit. Med. J.*, 1, 903 (1958).
[2] Brodie, B. B., Olin, J. S., Kuntzman, R. G., and Shore, P. A., *Science*, **125**, 1293 (1957).

PLANT PHYSIOLOGY

Absence of Gibberellin-like Substances in Filtrates of *Marasmius perniciosus* Stahel (Witch Broom Disease of Cacao)

Cacao plants (*Theobroma cacao*) infected with *Marasmius perniciosus* produce excessive and abnormal branching, a condition known as witch broom disease. It has been suggested by Brian[1] that symptoms may be caused by the production of growth-stimulatory or auxin-like substances by the pathogen. The morphological effects of gibberellic acid sprayed on cacao seedlings suggested that the 'brooming' effect of *M. perniciosus* might be caused by the production *in vivo* of gibberellin-like compounds by the fungus (Nichols, unpublished data).

This communication describes an attempt made to detect the production of growth-stimulatory substances or gibberellin-like compounds from a strain of *M. perniciosus* freshly isolated from an infected

cacao tree, by the application of culture filtrates and expressed cytoplasmic constituents to cacao and rice seedlings (*Oryza sativa*). These two test species were chosen because cacao is one of the host plants of *M. perniciosus*, and rice is known to respond to gibberellic acid. Plants treated with the uninoculated medium were used as controls, and plants treated with culture filtrates of *Fusarium moniliforme* grown in the same medium were used as an index of the production and behaviour of gibberellic acid. Preliminary experiments with gibberellic acid confirmed that rice seedlings responded to application of the solution of the acid under the conditions of our test.

In order to prepare culture filtrates, the organisms were grown on the following medium, which gave good growth: hydrolysed molasses, 20·6 gm./l. total sugar; ammonium sulphate, 3 gm./l.; potassium dihydrogen phosphate, 3 gm./l.; 'Marmite', 5 gm./l. The medium was adjusted to *p*H 6·3 and dispensed in 100-ml. amounts in indented 250-ml. conical flasks. The cultures were grown on a rotary shaker at tropical room temperature (26–29° C.) for 20 days, by which time sugar utilization was complete (97 per cent). The cultures (20 flasks) of each organism were combined and filtered through sintered glass, after which the sugar concentration in the clear filtrates was restored to that in the uninoculated medium by the addition of equal amounts of glucose and fructose. The *p*H was also adjusted to its initial value. The culture filtrates and control medium were concentrated eightfold by evaporation under reduced pressure at 40° C.

The effect of the concentrated filtrates on growth was examined by application of 0·1-ml. amounts to the terminal buds of cacao seedlings about 4 weeks from germination, grown in seed boxes. Each solution was tested on 12 plants. The plants were treated twice-weekly at 3- and 4-days intervals for a total period of 4 weeks. Concentrated and unconcentrated filtrates were tested in this manner. The *Fusarium* filtrates gave a marked elongation of the stem by typical internode elongation as compared with the control plants, but no effect either stimulatory or inhibitory was observed with the *Marasmius* filtrates. Similar results were obtained when the filtrates were applied to rice seedlings.

Despite the negative results with cultures grown *in vitro*, it remained possible that the substances responsible for the growth abnormalities of cacao were produced by the *Marasmius in vivo* in the host plant. This possibility was examined by treating seedlings with an extract of infected cacao tissue. The extract was prepared by macerating freshly collected witch broom branches (250 gm.) in a Waring blendor with a little water and expressing the mucilaginous pulp through several layers of cotton gauze. The filtrate was concentrated approximately ten-fold by evaporation to a thick gel in a freeze-drying apparatus. Cacao seedlings were treated by application of the extract to the stem just below the terminal bud. Some of the seedlings were pricked after the initial application to ensure entry of the extract into the plants. Treatment was continued twice weekly for 4 weeks. The extract had no effect whatsoever on the growth-rate relative to untreated control plants. These experiments suggest that *M. perniciosus* does not produce a detectable growth-stimulatory substance similar to gibberellic acid under the conditions of the culture and test whereas *F. moniliforme* does.

The strain of *F. moniliforme* (N.R.R.L. 2284) was kindly supplied by Dr. C. W. Hesseltine and the gibberellic acid by Dr. P. W. Brian.

W. F. Dudman
Colonial Microbiological Research Institute,
Port-of-Spain, Trinidad.

R. Nichols
Regional Research Centre,
Imperial College of Tropical Agriculture,
Trinidad.

[1] Brian, P. W., *Symp. Soc. Exp. Biol.*, **11**, 166 (1957).

Interaction of Magnesium and Adenosine Diphosphate in Photosynthetic Phosphorylation

A critical ratio of magnesium and the adenosine phosphates has been observed in several enzymically catalysed reactions. Hers[1] demonstrated that maximal activity in the hexokinase and fructokinase reactions occurred when the magnesium/adenosine triphosphate ratio was one. The rate of formation of adenosine diphosphate from adenosine monophosphate and adenosine triphosphate, catalysed by myokinase, was maximal when the magnesium/adenosine triphosphate ratio was one; in the reverse reaction, maximal activity was observed when the ratio was one half[2]. A definite stoichiometry between adenosine triphosphate and manganese also has been found, for Lowenstein[3] observed that maximal activity in a non-enzymic transphosphorylation occurred when the manganese/adenosine triphosphate ratio was approximately 1·7.

Arnon *et al.*[4] reported that magnesium enhanced photosynthetic phosphorylation. Avron *et al.*[5] have given results of the saturation of photosynthetic phosphorylation by magnesium and adenosine diphosphate in the presence of constant amounts of adenosine diphosphate and magnesium, respectively. It may be calculated from their results that in the presence of 1·5 μmoles adenosine diphosphate the system was saturated by 2·5–3 μmoles magnesium; in the presence of 5 μmoles magnesium the system was saturated by 2·25–2·5 μmoles adenosine diphosphate. Thus saturation was reached when the magnesium/adenosine diphosphate ratio was two. We have performed additional experiments, the results of which indicate that a definite ratio of magnesium and adenosine diphosphate is necessary for optimal photosynthetic phosphorylation.

Chloroplasts were prepared by grinding 25 gm. of spinach leaves, from which the petioles and mid-ribs had been removed, with sand and 25 ml. homogenizing solution in a mortar. The homogenizing solution was 0·02 *M* with respect to *tris* buffer *p*H 8·0, 0·3 *M* with respect to sucrose, and 0·004 *M* with respect to sodium chloride. Cellular debris was removed by filtering through cheese-cloth. The juice was centrifuged at 100*g* for 1 min., and this supernatant was centrifuged for 7 min. at 1,000*g*. The sedimented chloroplasts were suspended in 5 or 10 ml. of the homogenizing solution. These operations were performed at 5° C. Chlorophyll concentration was determined by Arnon's method[6].

The phosphorylation reaction was performed in Thunberg tubes. The reaction mixture contained 50 μmoles *tris* buffer *p*H 8·0, 80 μmoles sodium chloride, 20 μmoles dipotassium hydrogen phosphate, 10 μmoles ascorbate, 0·1 μmole flavin mononucleotide, 0·1 ml. chloroplast preparation (50–100 μgm.

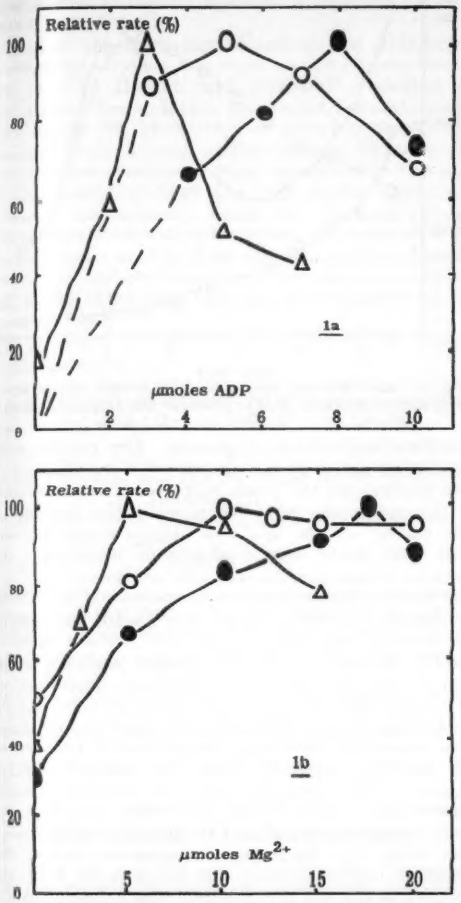


Fig. 1. *a*, Effect of concentration of adenosine diphosphate on photosynthetic phosphorylation. △, 5 μmoles magnesium; ○, 10 μmoles magnesium; ●, 15 μmoles magnesium. The rates corresponding to 100 per cent for △, ○ and ● were 70, 140 and 110 μmoles phosphate esterified/mgm. chlorophyll/hr., respectively. *b*, Effect of concentration of magnesium on photosynthetic phosphorylation. △, 3 μmoles adenosine diphosphate; ○, 5 μmoles adenosine diphosphate; ●, 8 μmoles adenosine diphosphate. The rates corresponding to 100 per cent for △, ○ and ● were 155, 100 and 104 μmoles phosphate esterified/mgm. chlorophyll/hr., respectively

chlorophyll), magnesium sulphate, adenosine diphosphate and water in a total volume of 3·0 ml. After trials had showed that phosphorylation occurred aerobically as well as anaerobically, all reactions were run in an atmosphere of air. The reaction vessels were held in a water-bath at 15° C. Illumination was provided by 150-watt reflector flood lights (intensity measured with a barrier layer photocell was approximately 1,800 foot candles). The reaction was allowed to proceed for 20 min., after which 0·5 ml. 20 per cent trichloracetic acid was added to each tube. Trichloracetic acid was added to control vessels either directly after the addition of chloroplasts or after 20 min. in darkness. The nucleotides were separated from inorganic phosphate by the method of Crane and Lipmann[7]. Phosphate was determined by the method of Taussky and Shorr[8]. Rates of phosphorylation were calculated from the disappearance of inorganic phosphate. The increase of organic phosphate was determined by hydrolysing the adsorbed nucleotides, but this increase was usually 5–20 per cent less than the amount of inorganic phosphate disappearing.

Fig. 1*a* shows the effect of adenosine diphosphate concentration on the rates of photosynthetic phosphorylation in the presence of three concentrations of magnesium. In the three cases the optimal rates of phosphorylation were observed when the magnesium/adenosine diphosphate ratio was 2. Fig. 1*b* shows the influence of magnesium concentration on the rates of photosynthetic phosphorylation in the presence of three concentrations of adenosine diphosphate. In these experiments also, optimal activity was observed when the magnesium/adenosine diphosphate ratio was 2. Magnesium usually showed a saturation effect; but in some instances inhibition was observed at higher concentrations.

It is clear that a definite magnesium/adenosine diphosphate ratio is necessary for optimal photosynthetic phosphorylation. Magnesium may affect more than one reaction in the process of photosynthetic phosphorylation; however, information on the overall reaction still is insufficient to evaluate the significance of the magnesium/adenosine diphosphate ratio of two.

This communication is published by permission of the Director of the Wisconsin Agricultural Experiment Station. The work was supported in part by a grant from the National Institutes of Health.

J. B. Mudd

Department of Biochemistry,
University of Wisconsin,
Madison 6, Wisconsin. Jan. 5.

[1] Hers, H. G., *Biochim. Biophys. Acta*, **8**, 424 (1952).
[2] Noda, L., *J. Biol. Chem.*, **232**, 237 (1958).
[3] Lowenstein, J. M., *Biochem. J.*, **70**, 222 (1958).
[4] Arnon, D. I., Whatley, F. R., and Allen, M. B., *J. Amer. Chem. Soc.*, **76**, 6324 (1954).
[5] Avron, M., Krogman, D. W., and Jagendorf, A. T., *Biochim. Biophys. Acta*, **30**, 144 (1958).
[6] Arnon, D. I., *Plant Physiol.*, **24**, 1 (1949).
[7] Crane, R. K., and Lipmann, F., *J. Biol. Chem.*, **201**, 235 (1953).
[8] Taussky, H. H., and Shorr, E., *J. Biol. Chem.*, **202**, 675 (1953).

Synergistic Effect of Zinc and Gibberellin

Dwarf beans (*Phaseolus vulgaris*) were sown in John Innes seed compost and, when emergence had occurred, the seedlings were transplanted into 2½-in. pots using the John Innes potting compost.

The plants were put in a growth room maintained at 60° F. and illuminated for 15 hr. a day with a bank of fluorescent lights giving 500–600 foot candles at the primary leaf surface of the beans. The plots were arranged in three 4 × 4 Latin squares, and 0·5 ml. gibberellic acid solution containing 500 mgm./l. 'Gibrel' was applied to the leaves of half the plants when elongation of the apical bud had commenced. ('Gibrel' is the potassium salt of gibberellic acid as produced by Merck and Co., Rahway, N.J., U.S.A.) 24 hr. later half the gibberellin-treated and half the remaining plants were treated with 0·5 ml. 10^{-2} *M* solution of zinc sulphate. Thus four treatments were obtained: 0, control; 0 + Zn, 10^{-2} *M* zinc sulphate; G, gibberellin solution; G + Zn, gibberellin plus zinc solution.

The elongation of the second internode, that is, that between the first and second trifoliate leaves, was measured one week after the application of the gibberellin. A further measurement was taken three days later.

There was a significant difference between the gibberellin treatment and controls, as would be

Table 1. The Effect of Zinc on the Response of Dwarf Bean Plants to Gibberellin

Treatment	Stem elongation (mm.) recorded after treatment	
	7 days	10 days
0	3·8	5·9
0 + Zn	4·8	8·1
G	15·2	52·8
G + Zn	20·8	70·6
Difference required for significance		
P (0·05)	4·1	10·1
P (0·01)	5·6	13·7

expected, but there was also a significant effect ($P = 0{\cdot}01$) between those treated with gibberellin and gibberellin plus zinc solution, the addition of zinc sulphate solution to plants already treated with gibberellin increasing the growth response. Solutions of sulphates of iron, manganese and potassium have not given similar increases in response and one (copper sulphate) reduced growth significantly. It is therefore assumed that the zinc ion was responsible for the effect reported here.

There was a slight, although not statistically significant, increase in the internode-length of plants treated with zinc alone, which may possibly have been due to the effect of the ion on the naturally occurring gibberellin-like substances in the plant.

This work was a continuation of studies started in the Department of Vegetable Crops, Cornell University. The gift of 'Gibrel' from Dr. J. Merritt of the Merck Chemical Co. is acknowledged.

John Dancer

Department of Horticulture,
University of Nottingham School of Agriculture,
Sutton Bonington,
Loughborough. Jan. 5.

MICROBIOLOGY

Endogenous Metabolism of Freshly Harvested Cells of a Brewer's Yeast

Washed cell suspensions of yeast have been reported as being able to respire their carbohydrate reserves but unable to ferment these reserves even when the cells were freshly harvested[1,2]. Other workers have reported that an alcoholic fermentation of these reserves is induced in the presence of dinitrophenol, azide and arsenite[3,4]. In the present work it has been found that in a brewer's yeast (*Saccharomyces cerevisiae*) the carbohydrate reserves are degraded by a fermentation process under both aerobic and anaerobic conditions. As a result of this fermentation the total carbohydrate content of the yeast in a suspension at 28° C. decreased by as much as 50 per cent in the 5 hr. following harvesting. The decrease in the trehalose and glycogen fractions accounted for all the loss of carbohydrate.

The yeast was grown up in the medium described by Spiegelman and Nozawa[2]. The incubation temperature was 25° C. The cultures were harvested after 48 hr., washed three times by suspension and centrifugation in $M/15$ potassium dihydrogen phosphate (pH 4·5) and then suspended in the same solution. Manometric measurements of respiration and fermentation were by the direct Warburg method at 28° C. The first manometric readings were always taken less than an hour after harvesting. Yeast carbohydrate was fractionated by the scheme described by Trevelyan and Harrison[5] and measured by an anthrone procedure. Ethanol in the suspending medium was distilled off and determined

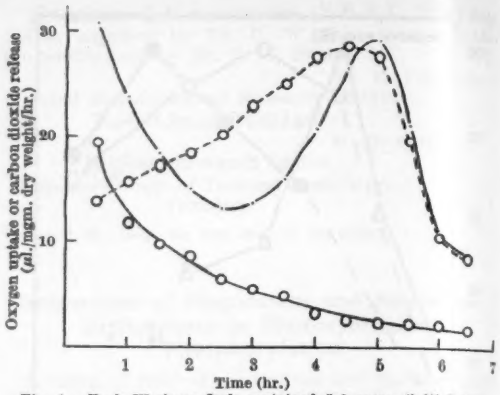


Fig. 1. Each Warburg flask contained 5·8 mgm. (initial dry-weight) of yeast in 3 ml. of $M/15$ potassium dihydrogen phosphate. $Q\mathrm{CO_2}(N_2)$, O—— O; $Q\mathrm{O_2}$, O- - - O; $Q\mathrm{CO_2}$, ——·

with liver alcohol dehydrogenase. Dry weights were determined after 48 hr. at 100° C. At the end of each experiment the yeast suspension was examined by the methylene blue technique. The number of cells taking up the dye was always negligible and there was never any evidence of autolysis. No bacterial contamination was ever observed.

In a series of experiments under anaerobic conditions the decrease in carbohydrate was 85–100 per cent of the amount calculated from the carbon dioxide released (assuming that each glucose molecule in the reserve carbohydrate produces two molecules of carbon dioxide and two molecules of ethanol during the fermentation). The ethanol which accumulated under anaerobic conditions was about 70 per cent of the amount expected from the carbon dioxide released. The $Q\mathrm{CO_2}(N_2)$ (μl. of carbon dioxide released per mgm. initial dry-weight of yeast per hour) had an initial value of 16–20 and decreased with time (Fig. 1). In other experiments where the release of carbon dioxide was followed for 9 hr. the $Q\mathrm{CO_2}(N_2)$ at the end of this period was still measurable.

Under aerobic conditions the endogenous fermentation was made apparent by a high initial respiratory quotient (1·9–2·5) and the production of ethanol. The ethanol accumulated for 2 hr. and then disappeared from the suspension. The time course of the endogenous metabolism is shown in Fig. 1. $Q\mathrm{O_2}$ (μl. of oxygen taken up per mgm. initial dry-weight of yeast per hour) in these experiments had an initial value of 12–14 and then increased to about 28 in about 4½ hr. before falling steeply. $Q\mathrm{CO_2}$ had an initial value of 28–32, which decreased for about 2½ hr. before increasing again to the same level as $Q\mathrm{O_2}$.

The apparent respiratory quotient falls rapidly from its high initial value to about 0·6 after about

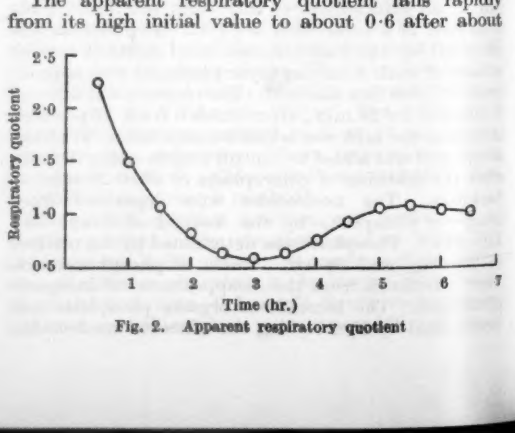


Fig. 2. Apparent respiratory quotient

3 hr. before increasing again to a constant value of about 1·03 (Fig. 2).

Most of the work carried out on the endogenous metabolism of yeast has been on cell suspensions[1–4], but in 1901 Harden and Rowland[6] described an endogenous fermentation in pressed brewer's yeast, resulting in the production of about equimolecular amounts of alcohol and carbon dioxide. These results with pressed yeast have been questioned[1,2,7] because of the possibility that the cells might have been damaged mechanically during the pressing process. The present work with cell suspensions shows that the brewer's yeast used in these experiments does degrade its reserve carbohydrate by a fermentation process, and at the same time the rate of respiration of the yeast doubles.

It is hoped to publish these results in greater detail elsewhere.

I wish to thank the directors of Arthur Guinness Son and Co. (Park Royal), Ltd., for permission to publish this work.

V. E. Chester

Arthur Guinness Son and Co. (Park Royal), Ltd.,
Laboratory,
Park Royal Brewery,
London, N.W.10.

Nov. 11.

[1] Stier, T. J. B., and Stannard, J. N., *J. Gen. Physiol.*, **19**, 479 (1936).
[2] Spiegelman, S., and Nozawa, M., *Arch. Biochem.*, **6**, 303 (1945).
[3] Rothstein, A., and Berke, H., *Arch. Biochem. Biophys.*, **38**, 195 (1952).
[4] Brady, T. G., and Duggan, P. F., Résumés Com. 3ème. Congr. Int. Biochem., 92 (1955).
[5] Trevelyan, W. E., and Harrison, J. S., *Biochem. J.*, **63**, 23 (1956).
[6] Harden, A., and Rowland, S., *J. Chem. Soc.*, 1227 (1901).
[7] Trevelyan, W. E., "The Chemistry and Biology of Yeasts", edit. by Cook, A. H. (Academic Press, Inc., New York, 1958).

Allyl Alcohol as a Nutrient for Micro-organisms

Allyl alcohol has in recent years come into some use as a herbicide active against dormant seed. Experiments in progress in this Laboratory have shown that this compound is rapidly detoxicated by biological agencies when added to soil at the rate of 0·02–0·05 per cent; various bacteria capable of utilizing it for growth were isolated from enrichment cultures by plating on selective agar medium. (A few earlier investigators[1,2] have tested allyl alcohol with negative results as a carbon source for fungi and bacteria.)

The active bacteria were partly varieties probably of *Pseudomonas fluorescens* and *P. putida* and partly strains of *Nocardia corallina*. Their growth was tested in soil extract medium containing 0·5 per cent (vol.) allyl alcohol, 0·05 per cent ammonium sulphate, 0·05 per cent dipotassium phosphate and 0·02 per cent magnesium sulphate. Duplicate cultures were grown for one week on a rotating shaker at 25° C., the cells were collected by centrifugation and the amount of growth was measured by determination of nitrogen in the washed-cell deposit. Some representative results are shown in Table 1.

Only 2 among 22 strains of *Pseudomonas* spp. isolated by non-selective methods were able to utilize allyl alcohol. Several bacteria belonging to other genera were tested qualitatively with negative results. All bacteria that grew with allyl alcohol could also utilize propanol and sodium propionate,

Table 1

Organisms		Cell nitrogen (mgm.) from 100 ml. medium	
		+ Allyl alcohol	Control
Pseudomonas spp. (7 strains)	Min.	2·2	0·2
	Max.	6·8	0·5
	Mean	5·0	0·4
Nocardia corallina (3 strains)	Min.	3·2	0·3
	Max.	4·8	0·5
	Mean	4·1	0·4

but the reverse did not apply. Among 40 strains of *Azotobacter* and *Beijerinckia* spp. two strains of *A. vinelandii* and one of *A. insigne* utilized allyl alcohol for nitrogen fixation; some 14–20 mgm. nitrogen were fixed per gm. of allyl alcohol supplied.

Also several strains of the fungus *Trichoderma viride* were able to use allyl alcohol for growth. Table 2 shows results found with seven strains grown for 20 days at 25° C. as stationary cultures in soil extract medium with 0·5 per cent (vol.) allyl alcohol. Four of these strains were isolated from selective medium and the rest non-selectively; the two groups of strains showed no essential difference.

Table 2

Dry weight of mycelium, mgm. per 100 ml. medium		
	+ Allyl alcohol	Control
Min.	14	1
Max.	160	5
Mean	90	3

A number of other fungi, collection cultures as well as random isolates from soil, were tested qualitatively with negative results; among these were also some strains of *Trichoderma viride*.

Experiments on the rate and mechanism of biological detoxication of allyl alcohol are in progress; the results will be published elsewhere.

I am indebted to Dr. Hans Lautrop, Statens Seruminstitut, Copenhagen, for supplying me with a number of strains of *Pseudomonas* spp.

H. L. Jensen

State Laboratory for Soil and Crop Research,
Department of Bacteriology,
Lyngby, Denmark.

Jan. 5.

[1] Coupin, H., *C.R. Acad. Sci., Paris*, **138**, 389 (1904).
[2] Den Dooren de Jong, L. E., "Bijdrage tot de kennis van het mineralisatieproces", thesis, Rotterdam (1926).

Mode of Division of Pediococci

The differentiation of pediococci from other groups of spherical lactic acid bacteria has frequently been based on the characteristic morphological arrangement into tetrads[1–3]. It has been generally assumed that the occurrence of tetrads is attributable to division in two planes[1,3]. However, some workers[4,5] have expressed the view that pediococci divide in one plane only, giving rise to chains similar to those formed by streptococci, and that tetrad formation is due to re-arrangement of 3–4 membered chains.

In all these investigations the mode of division has been deduced from examination of stained preparations only. It was decided, therefore, to follow the sequence of division of several strains, starting from single cells, by direct microscopic observation of developing slide cultures under a phase-contrast microscope. The cultures were made on semi-solid

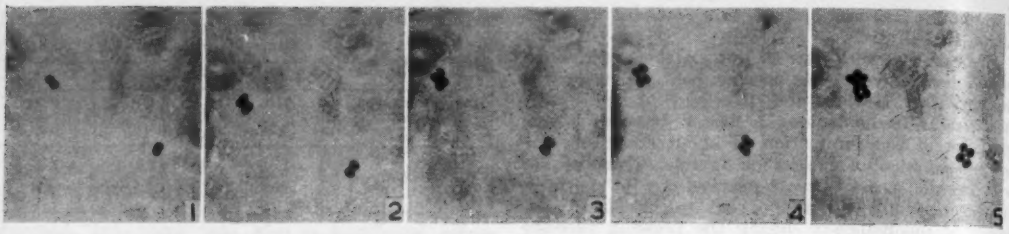


Fig. 1. Photomicrographs of division of *Pediococcus cerevisiae* strain 8081. Incubation for: (1), 0 hr.; (2), 1 hr. 45 min.; (3), 2 hr. 20 min.; (4), 3 hr. 20 min.; (5), 6 hr. 15 min. (× *c.* 710)

agar (tomato or glucose-yeast broth, *p*H 6·8 with 0·5 per cent Davis agar) and the microscope was fitted with a Newman Waterfield warm stage adjusted to 30° C. Series of photomicrographs were taken during the course of these observations, and one such series, which is representative of the sequence of divisions shown by all strains of pediococci studied, is reproduced in Fig. 1. The photomicrographs demonstrate clearly that division of pediococci occurs in two planes, and that successive divisions are approximately at right angles to each other.

Representatives of the streptococci, micrococci and sarcinae, studied under identical conditions, exhibited the typical modes of division associated with their respective groups.

The results of these experiments indicate clearly that the mode of division of the pediococci differs from that of the streptococci. In addition to their physiological differences, the two groups of organisms may be distinguished, therefore, on the basis of their morphology.

This work was undertaken during the tenure of a postgraduate scholarship awarded by Queen Elizabeth College (University of London).

Helge-Liane Gunther*

Department of Bacteriology,
Queen Elizabeth College,
University of London,
London, W.8. Jan. 7.

* Present address: Department of Pharmacology, Yale University School of Medicine, New Haven, Conn.

[1] Balcke, J., *Wschr. Brau.*, **1**, 257 (1884).
[2] Mees, R. H., Diss. Lab. A. J. Kluyver, Delft (1934).
[3] Pederson, C. S., *Bact. Rev.*, **13**, 225 (1949).
[4] Shimwell, J. L., and Kirkpatrick, W. F., *J. Inst. Brew.*, **45**, 137 (1939).
[5] Rohrer, E., *Schweiz. Brauerei Rundsch.*, **62**, 245 (1951).

A Gram-negative Sporing Bacterium from the Rumen

Reports in the literature of Gram-negative sporing bacteria are comparatively rare, although recently three have been mentioned[1–3], two from the rumen contents of cattle or sheep. We have obtained some Gram-negative sporing organisms during investigation of rumen bacteria. Three isolations were obtained from Gram-negative rods of the genera *Bacteroides* and *Butyrivibrio*[4] which had been isolated at different times from the rumens of sheep or cattle using a strictly anaerobic technique, based on that of Hungate[5], with either xylose or xylan as carbohydrate. Sporing forms were first noted on reculturing freeze-cried cultures. It seemed unlikely that the sporing bacteria were airborne contaminants, and although they were, under some conditions, very similar in morphology to the *Bacteroides* and *Butyrivibrio* spp. their properties always differed from these bacteria even after continued anaerobic culturing.

Two pure cultures of the sporing organism were obtained from the mixed cultures by micro-manipulation and culture of single spores, and a third by heat treatment of a sporing culture. A fourth isolation was made from the rumen contents of a sheep (not the one from which the original cultures were obtained). Although occasional sporing organisms of this type were seen in cultures made from dilutions of rumen fluid under anaerobic conditions it did not prove possible to isolate them anaerobically or by anaerobic followed by aerobic culture, so it was decided to use an aerobic technique, with xylose as carbohydrate, as this would destroy the similar Gram-negative non-sporing rods. To prevent overgrowth by other facultatively anaerobic organisms common to the rumen contents, penicillin (10 units/ml.) was incorporated in the diluting fluid and culture medium. Growth was obtained only to a dilution of rumen contents of 10^{-2}, and an isolation was made from the first dilution. All four isolations were similar straight or slightly curved rods (1·8–3μ × 0·8μ, but longer forms were seen), Gram-negative when stained in conjunction with known Gram-positive and -negative organisms, and having subterminal oval spores. Very occasional Gram-positive forms were also seen. Occasional motile cells were found, with a terminal flagellum. All grew aerobically or anaerobically, but better growth, and a lower *p*H in sugar media, were usually obtained aerobically. The spores of one isolation survived heating in physiological saline suspension in a boiling water-bath for 20 min., but were killed after 40 min.

Sugar fermentations were tested in a medium containing yeast extract and mineral salts incubated under carbon dioxide or aerobically. The fall in *p*H resulting from growth in sugar-containing media was not usually very great, and all reactions were checked with a Pye *p*H meter, a fall from 6·9 to 5·9 being considered positive. Xylose, glucose, fructose, mannose, galactose, lactose, cellobiose, melibiose, xylan, dextrin and amylopectin were fermented by all isolations with no visible gas formation. The fermentations of arabinose, maltose, trehalose, raffinose, glycogen, mannitol and α-methyl glucose were variable or indefinite. Rhamnose, fucose, inulin, salicin, æsculin, sorbitol, dulcitol, adonitol, glycerol, sodium succinate, lactate, malate, fumarate and citrate, were not fermented. Nitrate reduction, methyl red reaction and catalase production were positive. Voges-Proskauer and indole reactions, ammonia and hydrogen sulphide production, and urea and gelatin hydrolysis were negative. No growth was obtained in Koser's citrate medium, and the final *p*H in glucose–peptone broth was 5·2–5·6. Litmus milk was decolorized but no clot formed. The products

of fermentation of xylose, chosen to compare these bacteria with the *Bacteroides* and *Butyrivibrio* spp., were formic, acetic and lactic acids in the equivalent proportions 19 : 17 : 1. Succinic acid was not determined.

Antisera were prepared by inoculation of formolized suspensions into rabbits. Cross-agglutinations were found between the culture isolated directly from the rumen and the isolate from the culture of a sheep rumen bacterium. The two isolations from cultures of cattle rumen bacteria appeared to be serologically different from those of sheep. The one isolate tested was also different from the culture of *Bacteroides* sp. from which it was originally isolated.

In biochemical properties the bacteria resemble *Bacillus circulans*, but no motile colonies have been noted, although the growth was very thin and spreading on plates. It is not known whether the organisms play any part in rumen metabolism, although they must at times be present in fairly high numbers to have been isolated along with the cultures of *Bacteroides* and *Butyrivibrio* since these were taken from quite high dilutions of rumen contents. Appleby[6] isolated from the sheep rumen along with other proteolytic bacilli one culture, identified as *Bacillus circulans*, which liquefied gelatin. The Gram-negative sporing bacterium isolated by Gray[2] from the sheep rumen is said to resemble *Clostridium kluyverii* in properties. The present bacteria are somewhat similar in morphology to organisms described by Gutierrez[3], which were ingested by the rumen protozoan *Isotricha prostoma*, and possibly served as a nitrogen source for this protozoan.

We would like to thank Dr. K. I. Johnstone of the University of Leeds for obtaining one single-spore culture and for instruction in his micromanipulation technique to one of us (M. R. P.), Miss M. Garvock for the acid analyses, and Mr. S. O. Mann for discussion.

P. N. Hobson
M. R. Purdom

Rowett Research Institute,
Bucksburn,
Aberdeenshire.
Jan. 12.

[1] Gainor, C., *Bact. Proc.*, **60**, G, 103 (1957).
[2] Gray, F. V., *J. Bact.*, **76**, 535 (1958).
[3] Gutierrez, J., *J. Protozool.*, **5**, 122 (1958).
[4] Bryant, M. P., and Small, N., *J. Bact.*, **72**, 16 (1956).
[5] Hungate, R. E., *Bact. Rev.*, **14**, 1 (1950).
[6] Appleby, J. C., *J. Gen. Microbiol.*, **12**, 526 (1955).

GENETICS

A New Physical Method of creating Chromosomal Aberrations

Recent observations in this laboratory[1,2] have indicated a wide and unusual spectrum of effects which can be obtained from a radio-frequency source in the megacycle range. In order to minimize dielectric heating, it was necessary to reduce the mean power input and therefore we have used a pulsed radio-frequency source at 27 Mc./s. The pulses are of the order of 5×10^{-5} sec. Most of the effects described herein are produced with between 80 and 180 pulses per sec.

For microscopical and genetic studies we used two electrodes separated by an air gap of 3–15 mm. The electrodes were coupled to the primary radio-frequency source. There is a peak-to-peak voltage of about 1,000–1,500 V. The microscopic and genetic preparations were insulated from the electrodes by two layers of glass. It can be observed that a large variety of substances, including iron, carbon, silver, oil, fat droplets, starch grains and mammalian cells, will react to this field in two ways. First, any asymmetrical particle will be oriented with its long axis along the lines of force. Secondly, after orientation (which, of course, is not observed in symmetrical particles such as spheres) these particles will form chains along the lines of force as though they were iron filings between two poles of a magnet.

One of the most dramatic demonstrations of this effect can be seen when motile bacteria or protozoa are in this field. When the field is impressed, the micro-organisms can migrate only along the lines of force. As soon as the field is turned off, they resume their random movement. This can be repeated as many times as desired.

The thermal component is obviously sufficiently low so as not to affect the viability of these organisms or mammalian cells. In a larger, immobilized

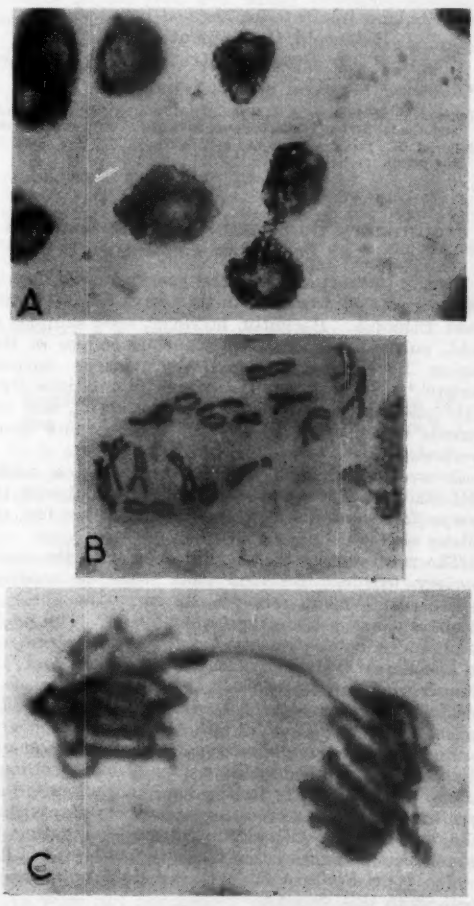


Fig. 1. Squash preparation of garlic root-tips 24 hr. after 5 min. of exposure in the electromagnetic field. *A*, Resting stage of an irradiated cell showing two nuclei linked by a chromatic bridge and no cytodieresis; *B*, metaphase with linear shortening of chromosomes; *C*, bridging

micro-organism we were able to observe intracellular orientation of subcellular particles. This led us to believe that this force might be used as a powerful and controlled mutagenic agent. Growing garlic root-tips in water were placed in a field between two insulated electrodes. No temperature increase in the water was noted. The tips were exposed for a 5-min. period and examined 24 hr. later.

Among those aberrations seen were linear shortening of chromosomes, pseudochiasmata, amitotic division, bridging, irregularities in the chromosomal envelope. The effects noted mimicked those produced by ionizing radiation and *c*-mitotic substances.

Fig. 1 shows some of the chromosomal aberrations observed. It is believed that this represents a new tool which may induce chromosomal aberrations to a degree contingent upon frequency, pulse, power, exposure time, and the axis of the cell *vis-à-vis* the field. Further experiments on the physical basis of these changes, as well as chromosome and mutation studies on other materials, are at present under investigation.

John H. Heller
A. A. Teixeira-Pinto*

New England Institute for Medical Research,
Ridgefield, Connecticut.
Dec. 24.

* Gulbenkian Foundation Research Fellow.

[1] Heller, J. H., and Cutler, J. L., Proc. Third Internat. Symp. Reticulo-endothelial System (Ronald Press, New York City; in the press).
[2] Heller, J. H., Teixeira-Pinto, A., and Cutler, J. L., *Res. Bull.* (in the press).

Preliminary Information on the Genetics of Ethiopian Coffees

Little is known about the genetic variability of the species *Coffea arabica* in its native home—south-west Ethiopia. Recently, however, seed samples of wild, cultivated and subspontaneous coffees in this region have been gathered by various agriculturists[1,2]. Several small seedling populations from Ethiopia were sent here in 1952 and 1953, and the genetic constitution of some of them is now being worked out.

It was noted that the 'Erithrean moca' coffee (*PI* 205 413, U.S. Dept. Agric.) is identical with the *semperflorens* mutant, being homozygous for the alleles *sfsf*[1].

The results of artificial pollination with the *murta* variety (*ttNana*) revealed that from 33 analysed coffee plants from Ethiopia, 23 carry the alleles *tt*, probably in the homozygous condition. The alleles *tt* characterize the variety *bourbon*, and its presence in Ethiopia indicates that this region and not Reunion Island, as formerly thought, is the place of origin of this important commercial variety. The *typica* variety (*TTNaNa*) also occurs in Ethiopia.

Plants of the *abyssinica* variety were frequently found in some of the seedling populations. Although the alleles responsible for its main characters are not yet known, it was noted that *abyssinica* plants carry the alleles *TT*. Other populations segregating for *abyssinica* characteristics bear the alleles *tt*. The coffee type *Ennarea* or *Ennaria*[1] does not seem to belong to this variety.

The genetic analysis of the colour of the young leaves revealed that the allele *br* is frequently found in the imported plants. A new recessive allele, *semierecta* (*se*) with a phenotypic effect somewhat similar to the dominant allele *erecta* (*Er*), was observed[2]. Plants with large fruits and seeds, *macrocarpa*, were noted but no information is available with regard to their genetic constitution.

Coffee seedlings with a small foliaceous and persistent calyx were found in the populations of plants identified as *S.4-Agaro* (*PI* 205 408) and *S.6-Cioccie* (*PI* 205 411) coffee. In spite of having developed sepals, these plants do not carry the allele *sd*[1]. An interaction, however, seems to occur between the *sd* and the allele or alleles responsible for persistent sepals from Ethiopia.

Other variations concerning: leaf shape; their position on the lateral branches; fruit shape; colour of the berry; period of fruit ripening and vegetative vigour, were also found.

This rather intensive variability encountered in the seedlings received from Ethiopia may be the result of a non-randomized procedure of seed collection, seeds very often having intentionally been harvested from more or less conspicuous variants, occurring in the Ethiopian coffee forests. Possibly a higher amount of natural cross-pollination, occurring in the native habitat of *C. arabica*, may also be responsible for this marked genetic heterogeneity.

The occurrence of several new genetic factors in such a small sample of Ethiopian coffee indicates that further exploration for coffee mutants in Brazil is highly desirable, to throw more light on the genetics of *Coffea arabica* and also to provide more basic material for its improvement.

Acknowledgment is due to Dr. C. A. Krug for help in the preparation of this communication.

Alcides Carvalho

Genetics Department,
Instituto Agronomico,
Campinas, São Paulo,
Brazil.
Jan. 5.

[1] Sylvain, P. G., *Turrialba*, **5** (1–2), 37 (1955).
[2] Sylvain, P. G., *Econ. Bot.*, **12**, 111 (1958).
[3] Krug, C. A., and Carvalho, A., "Adv. in Genet.", **4**, 127 (1951).
[4] Carvalho, A., *Tea and Coffee*, **31** (11), 30 (1958).

BIOLOGY

Generic Nomenclature of the Intermediate Hosts of *Schistosoma mansoni*

It has been shown by Hubendick[1] that the molluscan intermediate hosts of *Schistosoma mansoni* in Africa and South America are congeneric. The selection of the correct name for this genus of planorbid snails cannot be decided by a simple application of the rule of priority, because there is a conflict of opinion as to which is the oldest available name. The situation is further complicated by the fact that the names competing for precedence under the rule of priority are all quite unknown to the medical field workers and parasitologists who are frequently concerned in studies on these snails. An application has therefore been made to the International Commission on Zoological Nomenclature by Drs. F. S. Barbosa, B. Hubendick, E. A. Malek and myself asking for a decision which will stabilize the nomenclature of this economically most important group. It is probable that the decision of the Commission will not be made known for some time. It is for this reason that I am anxious to direct the

attention of workers who may be concerned with these snails to the normal practice of adhering to existing nomenclature while an application is before the Commission. Thus, until a decision has been given, the generic name used for the African intermediate hosts of *Schistosoma mansoni* should be *Biomphalaria* and for the South American hosts either *Australorbis* or *Tropicorbis*.

C. A. Wright

British Museum (Natural History),
Cromwell Road,
London, S.W.7. Jan. 5.

[1] Hubendick, B., *Trans. Zool. Soc. Lond.*, **28**, (6), 453 (1955).

Effect of Gamma-Radiation on Weeds

Considerable data are now available on the radiosensitivity of cultivated plants[1,2], but very little is known about the tolerance of wild species. We have investigated the doses of γ-radiation needed to prevent weed seeds from growing. The seeds were stored at 32 per cent relative humidity and irradiated in air with a range of doses from 0 to 100,000 rads of γ-radiation from cobalt-60. They were then planted in steam-sterilized soil and the number of plants arriving at maturity were counted. *LD*50 values for some common species of arable weeds are listed in Table 1.

Table 1. *LD*50 Doses for Arable Weeds

Species	Chromosome number (ref. 3)	Approximate *LD*50 (rads)
Plantago major	12	10,000
Anisantha sterilis	14	5,000
Alopecurus agrestis	14	20,000
Papaver rhoeas	14	30,000
Medicago lupulina	16 or 32	80,000
Brassica nigra	16	100,000
Atriplex patula	18	10,000
Anthemis arvensis	18	20,000
Raphanus raphanistrum	18	20,000
Sinapis arvensis	18	100,000
Veronica persica	28	>100,000
Galeopsis tetrahit	32	10,000
Sonchus oleraceus	32	10,000
Capsella bursa-pastoris	32	100,000
Polygonum convolvulus	40	30,000
Senecio vulgaris	40	80,000
Rumex obtusifolius	40	100,000
Avena fatua	42	20,000
Avena ludoviciana	42	20,000
Euphorbia helioscopia	42	20,000
Papaver dubium	42	30,000
Stellaria media	42	60,000
Galium aparine	44, 66 or 88	80,000
Cerastium vulgatum	144	80,000

Fig. 1 shows the effects of radiation on *Alopecurus agrestis* planted at a rate of 50 seeds per box. Several characteristic radiation effects were observed. Germination was not related to survival, as irradiated seedlings were generally weaker than controls, and often had distorted first leaves. Seedlings which survived matured later than controls but were not obviously distinguishable otherwise: induced sterility was frequently noted. The *LD*50 doses could not be correlated with any simple character such as chromosome number, though all plants with high chromosome numbers were always radioresistant. The species studied fall into two groups, those with *LD*50 doses less than 30,000 rads and those with *LD*50 doses, greater than 60,000 rads. Apart from *Raphanus* all the crucifers examined come in the second group and the four grasses in the first. *Anisantha sterilis* is remarkably radiosensitive, whereas *Veronica persica* must be one of the most radioresistant plants known.

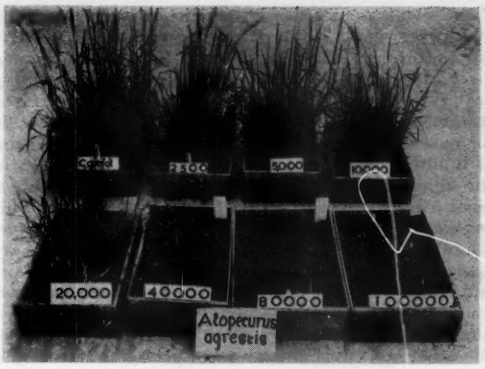


Fig. 1

The results obtained indicate that arable soils need treatment with at least 100,000 rads of γ-radiation to inhibit weed growth effectively. This treatment would sterilize any insects[4], or nematodes[5] present in the soil, and would probably destroy a high percentage of the bacteria[6,7] and fungi[7,8].

We wish to thank Mr. I. M. Rorison for supplying the seeds of *Papaver rhoeas* used in this work.

H. J. M. Bowen
S. R. Smith

Wantage Radiation Laboratory,
Grove, Berks.

[1] Gustafsson, Å., *Hereditas*, **30**, 165 (1944).
[2] Sparrow, A. H., and Christensen, E., *Science*, **118**, 697 (1953).
[3] Clapham, A. R., Tutin, T. G., and Warburg, E. F., "Flora of the British Isles" (Cambridge, 1950).
[4] Cornwell, P. B., Crook, L. J., and Bull, J. O., *Nature*, **179**, 670 (1957).
[5] Wood, F. C., and Goodey, J. B., *Nature*, **180**, 760 (1957).
[6] Dunn, C. G., *Sewage and Industrial Wastes*, **25**, 1277 (1953).
[7] Dunn, C. G., Campbell, W. L., Fram, H., and Hutchins, A., *J. App. Phys.*, **19**, 605 (1948).
[8] Zuckerman, B. M., *Phytopathol.*, **47**, 361 (1957).

Seasonal Changes in the Brain-case of the Common Shrew (*Sorex araneus* L.)

It is well known that shrews of the genus *Sorex* undergo a striking seasonal fluctuation in average weight and length of body[1]. This is mainly brought about by the annual turnover of the population and the rapid spring growth associated with sexual maturation. An additional contributory factor is the decrease in weight of the sub-adults as the winter of their year of birth approaches. This has been detected in large field samples of *S. araneus*[2,3], *S. fumeus*[4] and *S. vagrans*[5].

It was completely unsuspected, until discovered by Dehnel[3], that the autumnal depression in size of body was accompanied by a shrinkage in the size of the skull, the most striking change occurring in depth of the brain-case. Cabon[6] found a similar seasonal fluctuation in brain-case depth in *S. minutus*, and established that this was associated with changes in brain volume. The same seasonal change has been demonstrated in Polish *Neomys fodiens*[7], and in a collection of north German *S. araneus* in the Berlin Museum[8].

We were not completely satisfied that differences in depth of brain-case, of the order shown by Dehnel and his associates, could not be due to chance and the inevitable errors incurred with calipers, particularly as the samples for the crucial months were small.

The difficulties of attaining consistent accuracy when measuring small skulls with hand-operated calipers are notorious, as are the difficulties of introducing mechanical aids. Micrometers for use in engineering are commonly fitted with a means of applying a standard pressure between the jaws, but none suitable for measuring a small fragile object such as the skull of a shrew could be found. Mr. G. H. C. Jones, of the Science Museum, London, designed and made a measuring instrument specially for this purpose. This consisted of a lever pivoted near one end and counterpoised by means of a plunger within a solenoid. By operating a rheostat, a stylet attached to the short end could be brought to bear with constant pressure upon skulls resting on a metal plate. The measurement could then be read directly from a scale behind the other end of the lever. In order to measure depth of the brain-case, each skull was placed upside down upon the plate, the nasals resting on a wedge of 'Plasticine' to bring the floor of the brain-case to the horizontal. The stylet was then applied to the centre line of the basisphenoid. This gave the distance from the ventral surface of the basisphenoid to the highest point on the dorsal surface of the parietals. These measurements are smaller than those given by Dehnel[3] for brain-case depth in the same species, as his measurements were taken from the bullæ.

The depths of the brain-cases of 423 *Sorex araneus* from Wytham Estate, Berkshire, were measured in this way. The animals were taken in all seasons during October 1949–November 1951, and their reproductive condition and approximate ages were known. Thus it was possible to separate adults from young of the year, and to plot the changes in brain-case depth occurring within one generation of shrews. In Fig. 1 the means of depths of brain-cases in monthly samples of shrews born in 1949 are shown, together with the 95 per cent confidence limits of the means. It is clear that mean depth of brain-case decreases significantly between October and January, increasing thereafter until July, and then decreasing again as the end of the life-span approaches. The figures for the shrews born in 1950 show a similar trend although the samples are too small to be treated statistically.

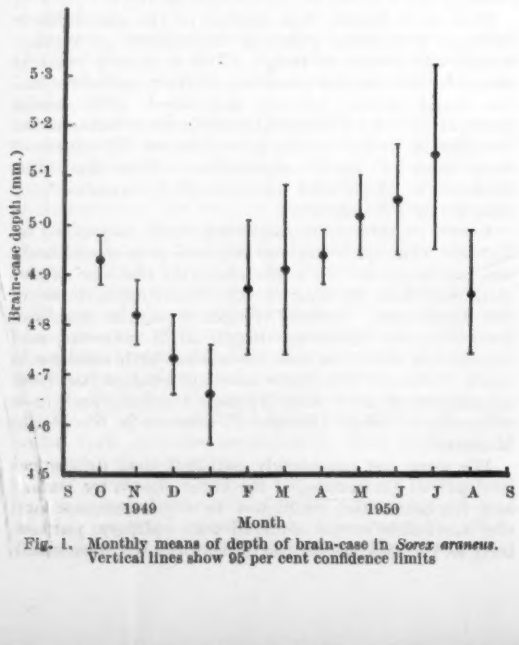


Fig. 1. Monthly means of depth of brain-case in *Sorex araneus*. Vertical lines show 95 per cent confidence limits

The hypothesis that the decrease in mean depth of brain-case is not due to shrinkage but to dilution of the population with small individuals from later litters cannot be supported, for the bulk of the annual 'crop' of common shrews is produced in June and July, very few females becoming pregnant as late as September. Furthermore, no breeding has ever been found to occur in *S. araneus* as late as December and January.

Thus Dehnel's "concertina" effect has been demonstrated in yet another population of common shrews and in a country with a much milder winter than that of eastern Europe. The more severe climatic changes suffered by the Continental shrews may account for their greater seasonal variation in brain-case depth. Similar studies of shrews from various regions of North America would be of great interest. Clothier[9] reported some variation in skull height in *Sorex vagrans* from Montana (U.S.A.), but it was not statistically significant. Similar studies of samples of this species from the extremes of its range may provide a means of assessing the effect of climate on seasonal skull variation.

In addition to recording our gratitude to the Director of the Science Museum, and to Mr. G. H. C. Jones, we wish to thank Mr. M. D. Mountford, of the Nature Conservancy, for carrying out the statistical analysis.

Peter Crowcroft
Jean M. Ingles

Zoology Department,
British Museum (Natural History),
London, S.W.7.

Jan. 13.

[1] Adams, L. E., *Mem. Proc. Manchester Lit. Phil. Soc.*, **54**, 1 (1910)
[2] Brambell, F. W. R., *Phil. Trans. Roy. Soc.*, B, **225**, 1 (1935).
[3] Dehnel, A., *Ann. U.M.C.S.*, C, **4**, 17, Pls. I–II (1949).
[4] Hamilton, W. J., jun., *Zoologica* (N.Y.), **15**, 473 (1940).
[5] Johnston, R. F., and Rudd, R. L., *J. Mamm.*, **38**, 157 (1957).
[6] Cabon, K., *Ann. U.M.C.S.*, C, **10**, 93 (1956).
[7] Pucek, Z., *Ann. U.M.C.S.*, C, **10**, 399, Pls. 13–19 (1957).
[8] Schubarth, H., *Acta Theriologica, Bialowieza*, **2**(9), 175 (1958).
[9] Clothier, R. R., *J. Mammal.*, **36**, 214 (1955).

Entry of Spermatozoa into the Fallopian-Tube Mucosa

It was reported recently that spermatozoon heads had been observed in the mucous membrane in histological sections of the Fallopian tube of two greater horseshoe bats (*Rhinolophus ferrum-equinum*) and four common pipistrelles (*Pipistrellus pipistrellus*)[1]; spermatozoa were not found in the uterine tissues. Similar observations have since been made in two rats, one rabbit, one hedgehog (*Erinaceus europaeus*), one mole (*Talpa europaea*) and two stoats (*Mustela erminea*). Spermatozoa considered to be in the mucosa were all in the thickness of the section and not on the surface. They were found even in individuals in which the lumina of tube and uterus contained few if any spermatozoa. When spermatozoon heads lay close to mucosal-cell nuclei, there was generally evidence of a local reaction, namely, a flattening or indentation of the opposed surface of the nucleus. Spermatozoa were not seen in sub-mucous tubal tissues. It is concluded, therefore, that the phenomenon is real, and not attributable to artefact, and that it is probably general.

In some respects, these observations resemble those of Kohlbrugge[2], who claimed to have identified

spermatozoa within the uterine mucosa in elasmobranch fish (*Scyllium* and *Torpedo*), the domestic fowl, bats of two species (*Xentharpya amplexicaudata* and *Pterogistes stenopterus*) and the rabbit, and also within the Fallopian-tube mucosa in the mouse. Spermatozoa were said to pass into the sub-mucous connective tissue of the uterine wall in *Xentharpya*. Kohlbrugge maintained that the invading spermatozoa exerted upon the uterus a trophic influence that not only played a part in the ensuing pregnancy, but also persisted and constituted part of the mechanism of telegony. Kohlbrugge's work and ideas have received support especially from Russian investigators[3]. However, serious doubts concerning the validity of conclusions drawn from histological studies have been raised by Vojtiskova[4]. She considers that previous reports, including her own earlier paper, were misleading because what the authors had interpreted as spermatozoa which had penetrated uterine tissues *ante mortem* were in reality luminal spermatozoa displaced during the preparation and cutting of the tissue and transferred to other parts of the sections. Consistently with this view, Austin[5], Pósalaky and Törő[6], and Edwards and Sirlin[7] announced that they could find no evidence that spermatozoa entered uterine tissues in the rat and mouse.

There is little doubt that, in the past, workers may often have been misled by artefacts in their material; but the new findings here described show that it would be rash to discount all previous reports on these grounds. Since incorporation of spermatozoa into the female tissues could have far-reaching immunological and genetic consequences, a re-investigation of the claims of Kohlbrugge and others is well justified.

I am greatly indebted to Dr. Ruth Deanesly for the opportunity of examining her histological preparations of material from *Pipistrellus*, *Erinaceus*, *Talpa* and *Mustela*, and to Mr. Michael Blackmore for collecting the specimens of *Rhinolophus*.

C. R. Austin

National Institute for Medical Research,
Mill Hill, London, N.W.7.
Jan. 13.

[1] Austin, C. R., and Bishop, M. W. H., *J. Endocrinol.* (in the press).
[2] Kohlbrugge, J. H. F., *Z. Morphol. Anthropol.*, **12**, 359 (1910); *Arch. EntwMech. Org.*, **35**, 165 (1913).
[3] Kushner, K. F., *Bull. Acad. Sci., U.R.S.S.*, B, No. 1, 32 (1954).
[4] Vojtiskova, M., *Folia Biol.*, **2**, 239 (1956).
[5] Austin, C. R., *J. Endocrinol.*, **14**, 335 (1957).
[6] Pósalaky, Z., and Törő, I., *Nature*, **179**, 150 (1957).
[7] Edwards, R. G., and Sirlin, J. L., *Endeavour*, **17**, 42 (1958).

An Abnormality in the Skin of Sheep

The normal procedure for fellmongering (removing the wool) English sheep skins is to paint the inner surface of the flayed skin with a paste of sodium sulphide solution thickened with lime. After allowing time for the chemicals to penetrate the dermis and dissolve the roots of the wool, the wool is pulled. The epidermis is also removed and the pelt is left in a semi-swollen condition. The pelt then goes forward to the subsequent processes of leather manufacture.

In the course of work on a new method of fellmongering involving treatment with proteolytic enzymes in place of sulphide and lime, the pelt, which is completely flaccid and unswollen when the wool is pulled, frequently showed a blistered effect on the grain (the epidermis – dermis junction forms the grain surface of the leather). The blisters appeared

Fig. 1. Diagram of sheep skin showing areas susceptible to blistering. The cross-hatched areas are those which most frequently show the defect, but it occasionally extends over the line-shaded areas

like small air bubbles up to about 3 mm. in diameter trapped under the grain, and they could be pushed around with the finger. They occurred only on fine-woolled skins and always in the areas around the hind shanks, occasionally extending a considerable distance towards the neck (Fig. 1). Lamb skins were affected more than sheep skins: in some packs of lamb skins as many as 40 per cent were affected. The phenomenon was independent of the temperature of treatment of the skins over the range 21–32° C.

The blisters were found microscopically (paraffin and frozen sections stained with azure *A*) to be associated with cavities occurring at all levels in the dermis. They were already present in the untreated skin and hence were not a condition induced by processing. Fig. 2 shows them in the papillary layer between the wool follicles of the untreated skin, and Fig. 3 in the dermis of the same section near the inner limiting layer. The wall of the cavity seems to be formed by the rearrangement, but not thickening, of ordinary fibres of the dermis. No contents such as fat, micro-organisms or infesting parasites have been observed within the cavities.

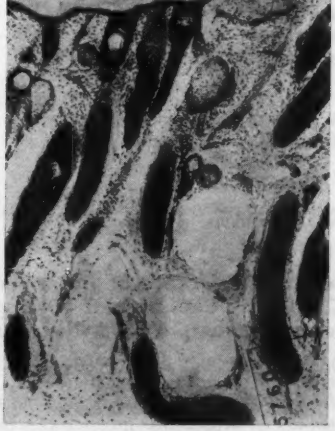


Fig. 2. Papillary layer of blistered sheep skin showing four cavities among the hair follicles (frozen section, azure *A*. × *c.* 57)

Fig. 3. Dermis of blistered sheep skin, near the inner limiting layer (frozen section, azure A. × c. 57)

No mention of this phenomenon is made by Seymour-Jones in his authoritative work on sheep skins[1]. Before sulphide and lime came into use, English skins were sweated, a bacterial process related to enzyme dewoolling but subject to much less control, which would leave the pelt in essentially the same flaccid condition as after enzyme treatment. It is possible that the condition was overlooked by Seymour-Jones, since the sweating process had long since been abandoned, or the breeds of sheep that were reared in the days of sweating were not subject to this phenomenon: there has been a progressive change in the types of sheep being bred over the past century. Apart from classifying the type of sheep subject to this blister as fine-woolled, no more exact designation can be given owing to the large amount of cross-breeding that is carried out resulting in the receipt by the fellmonger of miscellaneous types of cross-bred skins. The failure to observe the blisters in recent years is most likely due to the fact that the susceptible area is not often examined by leather microscopists, and to the probable collapse of the cavities during manufacture of the skin into leather.

Note added in proof. Since the above was written, Mr. J. Tate, who has been connected with the fellmongering industry for seventy years, has confirmed that sweated domestic sheep skins were subject to blistering, and the cause was unknown.

Mary Dempsey
G. H. Green

British Leather Manufacturers' Research Association, Milton Park, Egham. Jan. 15.

[1] Seymour-Jones, A., "The Sheep and its Skin" (The Leather Trades Review, London, 1913).

Abnormal Resistance of *Poria vaillantii* (D.C. ex Fr.) Cke. Strains to Copper–Chrome–Arsenate Wood Preservatives

Certain species of *Poria* causing brown rot in wood, including *P. vaporaria* (Pers. ex Fr.) Cke., *P. vaillantii* (D.C. ex Fr.) Cke., *P. xantha* (Fr.) Cke., and *P. monticola* Murr., are much more resistant to the toxic effects of simple copper salts than are most wood-destroying fungi, but have been readily inhibited by the copper–chrome–arsenate preservatives which are now in common use[1]. During wood-block tests of wood preservatives in this laboratory, however, one strain of *P. vaillantii* was found to be unaffected by these preservatives at the usual concentrations, and the tolerance of various strains of the species was therefore investigated by testing their ability to decay sawdust treated with increasing concentrations of such preservatives, using a modification of the sawdust dish–soil jar decay resistance test of Da Costa and Rudman[2].

A 4-gm. sample of air-dry sawdust (23–72 mesh) of the sapwood of *Pinus radiata* D. Don was mixed thoroughly with 7·5 ml. of the appropriate preservative solution, packed down tightly, and left 1–3 days to allow the preservative to distribute itself uniformly through the sawdust particles and to react with the wood components. The treated sawdust was then vacuum dried at 40° C. with frequent stirring, and 0·4 gm. samples placed in aluminium foil dishes (1 in. diam.; ¾ in. high) with perforated bottoms. The dishes of sawdust were sterilized by fumigation with propylene oxide and placed on pure cultures of the test fungus on thick filter paper disks, soaked in a solution of 2 per cent dextrose, 0·4 per cent casein hydrolysate, 0·4 per cent peptone, 0·05 per cent crystalline magnesium sulphate, 0·15 per cent potassium dihydrogen phosphate, 0·001 per cent thiamine hydrochloride, and resting on moist soil in glass jars. After incubation at 25° C. and 99 per cent relative humidity for 5 weeks, the dishes were vacuum dried and re-weighed and the amount of decay expressed as the percentage loss in oven-dry weight.

Initial tests with a typical proprietary preservative of the copper–chrome–arsenate type (Table 1) showed that the high tolerance previously noted was not shared by species of *Poria* of similar habit, or indeed by all strains of *P. vaillantii*. There were, however, three tolerant strains of very diverse origin, the most tolerant being *DFP*4443, which had been isolated originally from *Pinus radiata* treated with a copper-chromate preservative. This strain was used for making further tests with individual compounds commonly used in highly fixed water-borne inorganic preservatives of the metal–chrome–arsenate type.

Each compound was tested in a wide range of concentrations (for example, crystalline copper sulphate, 0·01, 0·015, 0·02, 0·03, 0·04, 0·06, 0·08, 0·12, 0·16, 0·24, 0·48, 0·64 'molal', where 1 'molal' has 1 gm. molecular weight added to 1,000 gm. of sawdust), and certain commonly used combinations

Table 1. Resistance of *Poria* spp. to a Copper–Chrome–Arsenate Preservative

Species	Isolate number *DFP*-	Origin	Amount of decay at preservative concentration*					
			0·0	0·1	0·4	1·6	3·2	6·4
Poria vaporaria (Pers. ex Fr.) Cke.	2392	England	57†	—	—	—	—	—
Poria xantha (Fr.) Cke.	3839	Australia	63	1	—	—	—	—
Poria sp.	6625	Australia	64	7	—	—	—	—
Poria sericeomollis (Rom.) Bax.	4911	Australia	67	17	1	—	—	—
Poria vaillantii (D.C. ex Fr.) Cke.	3112	Australia	35	—	—	—	—	—
	5227	Australia	62	41	—	—	—	—
	2375	England	51	56	52	51	13	—
	2446	Canada	62	53	55	36	25	2
	4443	New Zealand	58	61	64	39	38	20

* Gm. of dry salt added to 100 gm. oven-dry sawdust.
† Percentage loss in weight — mean of three replicates.

Table 2. Toxicity of Component Salts of Preservatives to *P. vaillantii* Strain *DFP* 4443

Preservative	Total inhibition point		
	'Molal' concentration	95 per cent fiducial limits	Percentage of dry salt
$ZnSO_4.7H_2O$	0·59*	0·14–2·53*	17·0†
$CuSO_4.5H_2O$	0·66	0·46–0·92	16·5
$Na_2Cr_2O_7.2H_2O$	0·37	0·27–0·51	11·0
As_2O_5	0·15	0·04–0·48	3·4
$CuSO_4.5H_2O$ + $Na_2Cr_2O_7.2H_2O$	0·33‡	0·16–0·70‡	18·1§
$CuSO_4.5H_2O$ + $Na_2Cr_2O_7.2H_2O$ + As_2O_5	0·25‡	0·15–0·44‡	19·4§
Copper–chrome–arsenate preservative	—	(16·0–31·6)†	23·0§

* Gm. molecular weights added to 1,000 gm. of oven-dry sawdust.
† Gm. of dry (not anhydrous) salt added to 100 gm. oven-dry sawdust.
‡ Concentration of each component.
§ Total percentage of all components.

were tested as equimolecular mixtures. From the dosage-response relationships obtained, the total inhibition point (that is, the minimum concentration of preservative necessary to reduce the weight loss to zero) was computed for each preservative (Table 2). For any one preservative the amount of decay produced was approximately in inverse proportion to the logarithm of preservative concentration: some preservatives showed significant, though slight, deviations from this relationship, and these have been taken into account in calculating the fiducial limits given.

The resistance of strain *DFP*4443 to copper and zinc is even higher than would be expected from previous reports on the copper-tolerant species of *Poria*, and this strain is also highly tolerant of arsenic. Later tests, in fact, show it to be more tolerant than *Lenzites trabea* (Pers.) Fr., which is widely used as an arsenic-tolerant fungus in testing wood preservatives. It is presumably this high tolerance of arsenic which distinguishes the strains found here to be tolerant of copper–chrome–arsenates from the *Poria* strains used elsewhere in tests of these preservatives.

I wish to acknowledge the assistance of Messrs. L. Bartak and J. M. Stephenson in these investigations, which will be reported more completely at a later date.

E. W. B. Da Costa

Division of Forest Products,
Commonwealth Scientific and
Industrial Research Organization,
Melbourne.
Dec. 12.

[1] Carr, D. R., New Zealand Forest Service, Forest Research Institute, Tech. Paper No. 4 and supplement No. 1 (1955).
[2] Da Costa, E. W. B., and Rudman, P., *Aust. J. Biol. Sci.*, **11**, 45 (1958).

Density-Dependent Factors in Ecology

Andrewartha's ideas on density-dependent factors[1] in ecology are very misleading, and have already been criticized by Huffaker[2]. I wish to refer to three points which he raises in his recent communication. First, he argues that since the population models of Lotka and Volterra are based on density-dependent relationships, and these have been "partly confirmed by laboratory experiments with such simple animals as *Paramecium*, but not with more complex ones such as *Calandra* and *Tribolium* and not with any sort of animal in Nature", this is evidence against the applicability of ideas of density dependency. Yet density-dependent relationships are known to operate in two ways in *Tribolium* cultures. Chapman[3] found the beetles ate their own eggs, and Boyce[4] showed female beetles laid fewer eggs when crowded. The Lotka–Volterra formulæ have seldom been applied to interpret these happenings because they are not properly applicable to animals with a long pre-reproductive period. However, Crombie[5] has used the formulæ with encouraging success to interpret the results of competition between the beetles *Oryzaephilus* and *Tribolium* and other grain insects.

Secondly, he quotes Nicholson's formula[6] relating the equilibrium population density N_E of an animal to its food supply g:

$$N_E = \frac{g - lg - wg}{q}$$

where l is the fraction of food lost to extraneous factors and w the fraction wasted by surplus individuals which fail to mature, and q the quantity of food required to complete development. By putting $w = 0$ or 1 Andrewartha claims to 'solve' the equation, whereas he is determining only the limits of possible solutions. Since w is itself a function of the population density N, a solution can be obtained only if the appropriate function of N is substituted for w. If, however, the competitive scramble for food wastes a negligible amount so that $w = 0$, then $N_E = \frac{(g - lg)}{q}$, which has a simple biological meaning. Andrewartha's categorical assertion that "This does not satisfy the concept of an equilibrium density" seems to be a *non sequitur*.

I agree with Andrewartha that the experiment he outlines to test the action of density-dependent factors is unable to prove anything; but far better methods are available. Density-dependent factors can be identified by their observed effects at a variety of population densities, and their ability to reduce high populations either asymptotically or with damped oscillations to the equilibrium density can be checked.

For the idea of density-dependency to be useful, the idea must be properly understood. If factors are to be invoked to explain population stability, they must have certain well-defined properties[7]. To use the term inappropriately and in senses entirely different from the original definition causes nothing but confusion.

G. C. Varley

Department of Entomology,
University Museum,
Oxford.
Jan. 27.

[1] Andrewartha, H. G., *Nature*, **183**, 200 (1959).
[2] Huffaker, C. B., Proc. Tenth Int. Congr. Entomol., **2**, 625 (1958).
[3] Chapman, R. N., "Animal Ecology", 188 (McGraw-Hill, 1931).
[4] Boyce, J. M., *Ecol.*, **27**, 290 (1946).
[5] Crombie, A. C., *Proc. Roy. Soc.*, B, **132**, 362 (1945); **133**, 76 (1946).
[6] Nicholson, A. J., *Aust. J. Zool.*, **2**, 9 (1954).
[7] Solomon, M. E., and Varley, G. C., *Nature*, **181**, 1778 (1958).

Andrewartha[1] has criticized an equation which he wrongly designates my "equation for intraspecific competition". Actually, it simply represents symbolically the necessary conditions for equilibrium in a postulated simple situation, other equations being given for other simple situations. His conclusion that "the equation is a tautology" is wholly due to his unjustifiable assumption that this equation is intended to represent the operation of competition.

The same assumption underlies his conclusion that the equation "does not satisfy the concept of an equilibrium density", arguing that "solving the equation for values of w between 1 and 0 gives values of N_E between 0 and $\frac{g - lg}{q}$". (w is the fraction of the governing requisite wasted by the animals which scramble for it, N_E the equilibrium density of the population, g the rate of generation of the governing requisite, l the fraction of this lost to the animals due to other agencies, and q the amount of the requisite required by an animal for development to maturity). The implication is that w, and therefore N_E, are indeterminate. However, as with the other parameters in the equation, the equilibrium value of w is determined by properties of the animals and those of the environment, and not by the equation. Andrewartha appears to have overlooked the statement[2], which immediately precedes the equation, that the "surplus individuals waste a fraction (w) of the governing requisite, in the sense that this fraction is rendered unavailable to those individuals which maintain the population by maturing and reproducing". Thus at equilibrium the value of w is positively related to the fraction of offspring which is surplus, and is influenced by the relation existing between crowding and the wastage (wg) of the governing requisite.

The equation under discussion is $N_E = \frac{g - lg - wg}{q}$, which does not purport to indicate how competition can bring about equilibrium. This question is discussed verbally and mathematically in neighbouring parts of the same article[2], but Andrewartha makes no reference to this discussion. It can readily be outlined by reference to the equation. Keeping in mind the fact that the fraction (w') of the governing requisite, say, food, which is wasted by the scrambling animals is positively related to the population density (N) at any given time, it is easy to see that when $N < N_E$ the wastage of food at that time is relatively low, that is, $w' < w$. More of the food is therefore available for the development of mature animals, and so $N \rightarrow N_E$, as similar arguments show it does when $N > N_E$. Thus competition among the animals sets up reactions which always tend to cause an approach to the equilibrium density. However, as the development of animals takes time, there tends to be an alternate over-shooting and under-shooting of the equilibrium density, for there is a delay in the operation of the corrective reaction induced at any given density.

Having determined the diminution of egg production by adults, and the increase of larval mortality, due to the wastage of food caused by different degrees of crowding in cultures of *Lucilia cuprina*, I was able to deduce the very varied patterns of population-growth and maintenance and the greatly differing levels populations would maintain, or oscillate about, under different specified conditions. These deductions were tested experimentally by subjecting populations of this blowfly to the postulated conditions, and the results obtained always agreed closely with expectation. Some of these experiments have already been described[2,3]. They all clearly demonstrated the governing function of density-induced reaction, which was the primary hypothesis underlying my predictions. Many other investigators have also successfully used the underlying idea of 'density-dependent factors' to assist them in their experiments and observations. Andrewartha's claim that this idea has been unfruitful is untenable.

At no time have I argued, as Andrewartha claims, "that only density-dependent factors can keep a population from becoming extinct", except in the special sense that such factors alone can prevent populations in favourable situations from becoming so large that they endanger their own existence. The views I have expressed[4] are that animals are necessarily excluded from all inherently unfavourable regions; that within favourable regions they characteristically multiply when unchecked; and that growth to indefinitely large numbers is prevented by density-induced opposition, such as the depletion of requisites, which automatically adjusts populations at, or fluctuating about, levels related to the properties of the animals and those of their environments. There is no need to attempt the impossible task of proving a null hypothesis by an experiment of the kind Andrewartha mentions. The views I have just expressed form a positive hypothesis which not only can be, but already has been, tested and confirmed by many experiments, as I have just indicated.

A. J. Nicholson

Division of Entomology,
Commonwealth Scientific and
Industrial Research Organization,
Canberra.
Feb. 6.

[1] Andrewartha, H. G., *Nature*, **183**, 200 (1959).
[2] Nicholson, A. J., *Aust. J. Zool.*, **2**, 1 (1954).
[3] Nicholson, A. J., Proc. Eighth Internat. Congr. Entomol., Stockholm, 277 (1948); *Nature*, **165**, 476 (1950); **173**, 862 (1954); *Cold Spring Harbor Symposia*, **22**, 153 (1957).
[4] Nicholson, A. J., "Ann. Rev. Entom.", **3**, 108 (1958).

Fossil Reptiles from the Panchet Beds of India

While preparing an exhibition of nothosaurs and other reptiles of Triassic age from Poland (held at the Geological Society of London on January 28), I realized from Dr. W. E. Swinton's paper[1] that nothosaurs are found at widely separated localities along the shores of the ancient sea of Tethys, from Europe eastwards to Japan. It would thus be reasonable to expect further nothosaur remains anywhere in this belt.

Another band of deposits containing Triassic reptiles is known—part of the Gondwana System—this time stretching from South Africa to Central Asia. This meets Tethys in northern India. Here one should find a mixture of the two faunas and would look for nothosaurs together with a Gondwanaland reptile, which, like them, had a wide distribution and was aquatic. From the literature[2] I found that such an animal was already known from India, namely, the dicynodont *Lystrosaurus*.

Dr. G. de P. Cotter in 1917[3] in his "Revised Classification of the Gondwana System" suggested that the dicynodont material described by Huxley[4] and Lydekker[5] from the Panchet Beds of Bengal belonged to the genus *Lystrosaurus*, and used its presence to correlate these beds with the basal Trias of South Africa. He did not, however, discuss the material as he was concerned solely with stratigraphy. In 1922[6], the late H. C. Das Gupta, professor of geology in Calcutta, in his "Notes on the Panchet Reptile", gave the history of the genus in India and, by means of a detailed discussion of the

known skeletal elements, confirmed that Huxley's and Lydekker's material should be placed in *Lystrosaurus*. In addition, he described further *Lystrosaurus* remains that he himself had collected from the Panchet Beds.

Later, Das Gupta[7] described and figured from the same beds a small reptilian vertebra which he considered to be rhynchocephalian, but which is very similar to some of the nothosaur vertebræ from Poland, and is amphiplatyan not amphicœlous as in the Rhynchocephalia. I consider, therefore, that it belongs to a nothosaur.

Thus it would seem that Prof. Das Gupta, even though not aware of it, by finding both nothosaur and *Lystrosaurus* remains in the Panchet Beds, made an important contribution which may well help to effect a closer correlation of the Gondwana System with the Tethyan deposits than has hitherto been possible.

It is good to see that the work of these earlier writers, who had only fragmentary remains for study, should now be so fully confirmed by Dr. P. L. Robinson's account of the recent discovery of more complete remains of *Lystrosaurus* in India[8].

L. B. Tarlo

Department of Palæontology,
British Museum (Natural History),
London, S.W.7. Jan. 22.

[1] Swinton, W. E., *Ann. Mag. Nat. Hist.*, (Ser. 12), **5**, 875 (1952).
[2] Woodward, A. S., in Zittel's "Text-book of Palæontology", **2**, 259 (1932). Aiyengar, N. K. N., and Venkataram, M. S., *Rec. Geol. Surv. India*, **75**, Prof. Paper 7, 1 (1940). Romer, A. S., "Osteology of the Reptiles", 707 (1956). Holland, T. H., Krishnan, M. S., and Jacob, K., "International Stratigraphical Lexicon", **3**, Part 8, 196 (1957).
[3] Cotter, G. de P., *Rec. Geol. Surv. India*, **48**, 23 (1917).
[4] Huxley, T. H., *Pal. Indica*, Ser. 4, **1**, Part 1, 3 (1865).
[5] Lydekker, R., *Pal. Indica*, Ser. 4, **1**, Part 3, 1 (1879).
[6] Das Gupta, H. C., Sir A. Mookerjee Silver Jubilee Vol., **2**, 237 (1922).
[7] Das Gupta, H. C., *J. Asiatic Soc. Bengal*, N.S., **24**, 473 (1929).
[8] Robinson, P. L., *Nature*, **182**, 1722 (1958).

Many previous writers have suggested that the dicynodont present in the Panchet sandstones might be *Lystrosaurus*. Some, such as de P. Cotter, were not concerned with a review of the dicynodont material available but had some particular stratigraphic axe to grind. Others (Lydekker, Das Gupta, von Huene) have directed attention to certain features of the few fragments available. It is probably not possible to identify *Lystrosaurus* on such fragments. Many characters can be matched individually with those seen in some other dicynodont. A complex of characters, and in particular the key characters of *Lystrosaurus* which are dependent on the relative shortness of the temporal region as compared with length and depth of snout region, can obviously only be assessed on a reasonably complete skull. The matter has been well expressed by Das Gupta[1], " . . . without the discovery of an entire skull, the zoological position of the Panchet reptile cannot be definitely settled. . . ".

I take it that the vertebra diagnosed as nothosaurian by Tarlo is the worn centrum figured by Das Gupta in 1928[1] (Plate II, Fig. 4). The edges of the centrum are so abraded that I feel that a diagnosis of it as originally amphiplatyan is uncertain.

I believe that the description, by Tripathi and Satsangi of the Geological Survey of India, of the new *Lystrosaurus* remains from the lower Panchets, and a careful comparison with the South African and Chinese forms, will be a major contribution to our understanding of the stratigraphy of the Gondwana Group of India. I was delighted to hear from the director of the Geological Survey of India, Dr. B. C. Roy, that he had decided that field work on the Panchets should be continued, and that Tripathi and Satsangi are again making a collection from these rocks. We must wish them success and hope that further discoveries of good specimens of the Panchet fauna will relieve us of the need to burden the literature with identifications made on fragmentary bones.

Pamela Lamplugh Robinson

Department of Zoology,
University College, London.
March 5.

[1] Das Gupta, H. C., *J. and Proc. Asiatic Soc., Bengal*, **15** (1919); **24** (1928).

ENTOMOLOGY

Proepithelial Regeneration in the Midgut of Beetles

The columnar cells of the midgut epithelium in most insects are continually replaced by new cells produced by the division of special regenerative cells. The latter are usually scattered singly or grouped into nidi or else form deep crypts. Pradhan[1], however, described a new process in *Coccinella septempunctata* (Coleoptera, Coccinellidae) and other carnivorous coccinellids where the new cells (pro-epithelial cells) are grouped around large cavities or vacuoles. When the old epithelium is shed, the pro-epithelial cells move into their place. He states that "the presence of this peculiar process of regeneration (pro-epithelial regeneration) in the carnivorous coccinellids and its absence in the herbivorous species forms the most striking difference between the carnivorous and herbivorous midguts". However, in the case of *Epilachna vigintioctopunctata* Fabr., a common herbivorous coccinellid studied by us, pro-epithelial cells grouped around large vacuoles (about 20μ in diameter) could easily be seen (Fig. 1). The vacuoles are present throughout the midgut but are most clearly seen in the middle portion of it.

The function of the vacuoles is obscure. Pradhan[1] speculated that they have a macerative action and are responsible for shedding the old epithelium. In the present material it was noticed that the contents of the vacuoles are not purely watery but give a

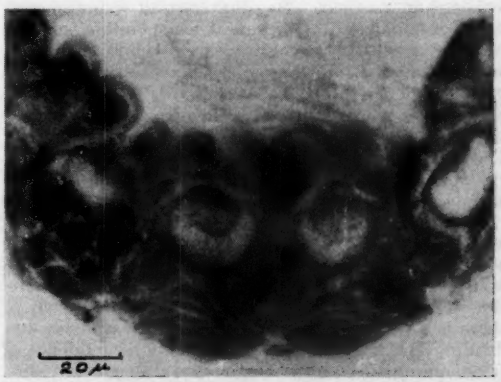


Fig. 1. Section through the middle portion of the midgut of *Epilachna vigintioctopunctata* showing the large vacuoles and the pro-epithelial cells around them

positive periodic acid Schiff reaction of MacManus[2]. Further studies on the vacuoles are in progress.

M. Ameen
S. A. Shafiq

Department of Zoology,
University of Dacca,
Pakistan. Jan. 12.

[1] Pradhan, S., *Quart. J. Micro. Sci.*, **81**, 451 (1939).
[2] MacManus, J. F. A., *Nature*, **158**, 202 (1946).

Respiration of Corixidae (Hemiptera-Heteroptera)

Pterygote insects originally evolved as terrestrial animals, but various families of Hemiptera have since colonized aquatic habitats. Corixids live on the bottom, feeding mainly on algae and detritus. Air carried on the hydrophobe body surface functions as a 'physical gill'[1-4]. The thoracic tracheal system is well developed. The ventrally situated anterior thoracic spiracles occur between the pro- and ptero-thorax. The dorsally placed posterior thoracic spiracles occur laterally to the wing bases. The anterior abdominal spiracles occur dorsally, just posterior to the thorax. On each side these spiracles are joined by a wide, lateral, longitudinal tracheal trunk, which supplies tracheæ to the flight and leg muscles. The tracheæ from each of the ventrally placed abdominal spiracles supply gonads and gut, but, except for the dorsally placed vestigial longitudinal tracheal trunks, are unconnected with other tracheæ of the same or adjacent segments. The passage of gas anteriorly through the thorax (a centre of high oxygen consumption) is largely independent of that through the abdomen where the consumption of oxygen is relatively low.

During submergence, gas is expired from the anterior thoracic spiracles into the space between the pro- and ptero-thorax, to be moved backwards over the surface of the body by the hind legs, which bear special hydrophobe setæ for this purpose. The abdomen is dorso-ventrally flattened to facilitate gaseous exchange between the gas stores and water. Oxygenated gas is inspired through the first pair of abdominal spiracles to pass forwards through the thorax. Considerations of the arrangement of the thoracic sclerites and metathoracic leg muscles show thoracic ventilation is probably automatic during swimming.

Corixids normally come to the surface when deficient in oxygen. By illuminating experimental tanks obliquely from one side it was possible to show corixids are positively phototactic while surfacing, and negatively phototactic when returning to the bottom. This implies that corixids are positively phototactic when deficient in oxygen and negatively phototactic when sufficient oxygen has been obtained. These conclusions are supported by independent evidence of the reactions of corixids to light before and during flight.

Corixids usually occur in shallow water. Hagemann's organs occur immediately in front of the posterior thoracic spiracles. Stimulation of these organs causes surfacing. Under natural conditions this occurs when corixids wander to a depth where there is a danger of water entering the spiracles and flooding the tracheal system. So far no evidence is forthcoming to confirm Hagemann's suggestion that this organ has an auditory function[5].

Corixids renew their superficial gas stores by momentary contact with the atmosphere. At the water surface the pronotum is raised from the front of the hemi-elytra and air rushes over the hydrophobe body surface to dilate the gas stores. Holdgate[6] has shown that aquatic insects with a roughened surface have a high advancing and retreating angle when wetted. During surfacing the rastration of the pronotal and corial surfaces of some species accelerates exposure of the pronotal-hemi-elytral junction and retards the return of water when gas store replenishment is completed.

Cutaneous respiration occurs in the early nymphal instars, but is gradually replaced in later instars and adults by the superficial gas stores acting as a physical gill. As nymphs grow, the increase of cuticular thickness and the reduction in the relative size of the body surface decrease the efficiency of the skin as a respiratory organ. This is compensated by a corresponding increase of relative gas store size: gaseous exchange occurring more rapidly through the air-water interface of the gas stores than through the cuticular body surface.

The physical gill is associated with secondary modifications of body form. The surface gas bubbles make the insect less dense than water. To progress along a horizontal path the hind legs are kicked backwards and upwards. This drives the corixid not only forwards but also slightly downwards to compensate for the tendency to float towards the surface between each leg kick[3]. This mode of locomotion is associated with a forward slant of the thoracic segments and an inward rotation of the hind coxæ: changes which are well illustrated by comparison of the thoracic segments of *Micronecta* and *Corixa*.

While copulating, corixids come to the surface several times. The sexes when joined cannot surface normally because the male is relatively immobile and the female, being ventral to the male, cannot make contact with the surface in the usual way. The male abdomen is asymmetrical and the ædeagus is extruded to the left in *Corixa punctata* and to the right in most British species. Surfacing is accomplished by the pair rolling over on the side of the male asymmetry, thereby allowing the other side of the abdomen ample freedom of movement for gas store replenishment.

In the Corixidae, the reduction of the longitudinal abdominal tracheæ has made it possible for gas to be passed anteriorly through the thorax and for the efficiency of the physical gill to be increased. Compared with other aquatic Hemiptera (for example, Nepidae, Naucoridae and Notonectidae) corixids are less directly dependent upon atmospheric oxygen. Their emancipation from the surface (though not so complete as in *Aphelocheirus aestivalis*[4]) has enabled the family to undergo adaptive radiation to a wide range of aquatic microhabitats and to evolve into more Palæarctic species than occur in the remainder of the Cryptocerata.

Edward J. Popham

Department of Zoology,
University,
Manchester.
Jan. 12.

[1] De Ruiter, L., *et al.*, *Acta Physiol. Pharmacol. Neer.*, **2**, 180 (1952).
[2] Ege, R., *Z. Allg. Physiol.*, **17**, 81 (1915).
[3] Popham, E. J., *Proc. Roy. Ent. Soc., Lond.*, A, **27**, 117 (1952); A, **29**, 51 (1954).
[4] Thorpe, W. H., and Crisp, D. J., *J. Exp. Biol.*, **24**, 227, 270, 310; **26**, 219 (1947–49).
[5] Hagemann, J., *Zool. Jb. Anat.*, **30**, 373 (1910).
[6] Holdgate, M. W., *J. Exp. Biol.*, **32**, 591 (1955).

FORTHCOMING EVENTS

Wednesday, April 1

INSTITUTE OF PETROLEUM (at 61 New Cavendish Street, London, W.1), at 5.30 p.m.—Mr. J. S. Elliott, Mr. N. E. F. Hitchcock and Mr. E. D. Edwards: "Hypoid Gear Lubricants and Additives".

SOCIETY OF CHEMICAL INDUSTRY, FOOD GROUP—NUTRITION PANEL (at 14 Belgrave Square, London, S.W.1), at 6.15 p.m.—Annual General Meeting, followed by Prof. Hugh Nicol: "Facts About Food Supplies".

INSTITUTION OF ELECTRICAL ENGINEERS, LONDON GRADUATE AND STUDENT SECTION (at Savoy Place, London, W.C.2), at 6.30 p.m.—Mr. S. J. Read: "Discriminators (F.M. Detectors) with particular reference to the Bond Disc".

SOCIETY FOR ANALYTICAL CHEMISTRY (at the Chemical Society, Burlington House, Piccadilly, London, W.1), at 7 p.m.—Scientific Papers.

Thursday, April 2

LINNEAN SOCIETY OF LONDON (at Burlington House, Piccadilly, London, W.1), at 5 p.m.—Prof. R. E. Holttum: "Growth-habits in Monocotyledons"; Mr. E. M. Marsden-Jones: "Genetics and Pollination of *Anagallis arvensis* subsp. *arvensis* and *A. arvensis* subsp. *Foemina*".

INSTITUTE OF REFRIGERATION (at the Institute of Marine Engineers, The Memorial Building, 76 Mark Lane, London, E.C.3), at 5.30 p.m.—Mr. W. R. Hall: "The Measurement and Determination of Noise in Small Refrigerating Machines".

INSTITUTION OF ELECTRICAL ENGINEERS (at Savoy Place, London, W.C.2), at 5.30 p.m.—Discussion on "Women in Engineering" opened by Sir Willis Jackson, F.R.S.

SOCIETY OF CHEMICAL INDUSTRY, MICROBIOLOGY GROUP (at 14 Belgrave Square, London, S.W.1), at 6 p.m.—Annual General Meeting, followed by Dr. P. W. Brian, F.R.S.: "Some Ecological Consequences of Production of Extracellular Metabolites by Micro-organisms".

POLAROGRAPHIC SOCIETY (at "The Duke of York", 8 Dering Street, London, W.1), at 7 p.m.—Informal Discussion Meeting on "Some Polarographic Problems Encountered in Industrial Medicine" introduced by Mr. K. Baker and Mr. L. King.

Friday, April 3

BIOCHEMICAL SOCIETY (in the Department of Biochemistry, University College, Gower Street, London, W.C.1), at 10.30 a.m.—Annual General Meeting.

MANCHESTER STATISTICAL SOCIETY, INDUSTRIAL GROUP (in the Portico Library, 57 Mosley Street, Manchester), at 6 p.m.—Mr. L. H. C. Tippett: "Recent Developments in the Measurements of Productivity in the Textile Industry".

SOCIETY OF DYERS AND COLOURISTS, LONDON SECTION (at the George Hotel, Luton), at 7 p.m.—Dr. T. Vickerstaff: "Recent Developments in Dyeing".

APPOINTMENTS VACANT

APPLICATIONS are invited for the following appointments on or before the dates mentioned:

CHAIR OF PHILOSOPHY tenable in the Durham Division of the University—The Registrar, University Office, 46 North Bailey, Durham (April 9).

LECTURERS (with a good honours degree and relevant teaching experience) IN GEOGRAPHY, CHEMISTRY, PHYSICS AND MATHEMATICS at the Nigerian College of Arts, Science and Technology—The Council for Overseas Colleges, 12 Lincoln's Inn Fields, London, W.C.2 (April 10).

RESEARCH FELLOW (with an interest in physical-organic chemistry and some postgraduate experience in preparative chemistry) IN THE DEPARTMENT OF CHEMISTRY—The Registrar, Queen Mary College (University of London), Mile End Road, London, E.1 (April 10).

SENIOR LECTURER (with a good honours degree and some previous teaching experience) IN MATHEMATICS—The Director of Education, The Polytechnic, 309 Regent Street, London, W.1 (April 10).

LECTURER IN ORGANIC CHEMISTRY—The Clerk to the Governors, Chelsea College of Science and Technology, Manresa Road, London, S.W.3 (April 13).

ASSISTANT EXPERIMENTAL OFFICER or EXPERIMENTAL OFFICER (zoologist, preferably with an interest in entomology) at the Freshwater Fisheries Laboratory, Pitlochry, to be a member of a small team working on the bottom fauna of freshwaters—The Establishment Officer, Scottish Home Department, Room 364, St. Andrew's House, Edinburgh 1 (April 15).

PROFESSOR OF APPLIED PHYSICS in the Durham Division for a new Department of Applied Physics due to open in October 1960—The Registrar, University Office, 46 North Bailey, Durham (April 16).

LECTURER (graduate with qualifications, training and teaching experience in mathematics) IN THE DEPARTMENT OF EDUCATION—The Registrar, The University, Leicester (April 18).

RESEARCH ASSISTANT (with an honours degree in statistics or an honours degree in mathematics, together with some knowledge of statistical methods) IN STATISTICS, for duties which include computation, programming for a computer, demonstration and a small amount of teaching—The Registrar, The University, Sheffield (April 18).

RESEARCH FELLOW (with Ph.D. or equivalent experience in an appropriate subject, such as biochemistry, animal or plant physiology) AT THE MARINE BIOLOGY STATION, for research into mechanisms of toxicity—The Registrar, University College of North Wales, Bangor (April 18).

ASSISTANT LECTURER IN PHYSICS—The Registrar, University College of North Staffordshire, Keele, Staffs (April 20).

LECTURER (preferably medically qualified) IN PHYSIOLOGY—The Secretary, The University, Aberdeen (April 20).

TECHNICIAN (preferably with experience in workshop practice or in histological techniques) AT THE MARINE BIOLOGY STATION—The Registrar, University College of North Wales, Bangor (April 20).

UNIVERSITY DEMONSTRATORS and DEPARTMENTAL DEMONSTRATORS IN BIOCHEMISTRY, ECOLOGY, PHYSIOLOGY and VIROLOGY—The Sherardian Professor of Botany, Botany School, The University, Oxford (April 20).

TUTOR or LECTURER (woman, with special qualifications in either experimental or theoretical physics) IN PHYSICS—The Treasurer, Somerville College, Oxford (April 21).

SENIOR LECTURER or LECTURER IN PHILOSOPHY at the University of Khartoum—The Secretary, Inter-University Council for Higher Education Overseas, 29 Woburn Square, London, W.C.1 (April 23).

CHAIR OF PHYSIOLOGY at Bedford College—The Academic Registrar, University of London, Senate House, London, W.C.1 (April 24).

RESEARCH ASSISTANT (with a first- or second-class honours degree in chemistry) IN THE CHEMISTRY AND METALLURGY DEPARTMENT—The Principal, Coventry Technical College, Butts, Coventry (April 24).

LECTURER or ASSISTANT LECTURER IN THE DEPARTMENT OF ZOOLOGY AND COMPARATIVE PHYSIOLOGY—The Registrar, The University, Birmingham 15 (April 25).

ASSISTANT LECTURER IN INORGANIC CHEMISTRY—The Registrar, The University, Hull (April 27).

READER IN GEOGRAPHY at Queen Mary College—The Academic Registrar, University of London, Senate House, London, W.C.1 (April 27).

CLINICAL LECTURER (medical graduate with experience in bacteriology, immunology or virology, and in research methods) IN MICROBIOLOGY—The Secretary, Association of Universities of the British Commonwealth, 36 Gordon Square, London, W.C.1, or The Registrar, University of Otago, Dunedin, New Zealand (New Zealand, April 30).

RESEARCH ASSISTANT (with an honours or good pass degree in agriculture or equivalent) IN THE DEPARTMENT OF AGRICULTURE, for grazing studies in connexion with grassland irrigation—The Registrar (Room 22, O.R.B.), The University, Reading (April 30).

UNIVERSITY LECTURER IN HISTORY OF SCIENCE—Mr. R. F. Holmes, The Old Schools, The University, Cambridge (April 30).

SENIOR LECTURER IN PHYSICS—The Registrar, The University, Hull (May 1).

ASSISTANT LECTURER or LECTURER (preferably with a special interest in mineralogy and petrology or in economic geology) IN GEOLOGY at the University College of Ghana—The Secretary, Inter-University Council for Higher Education Overseas, 29 Woburn Square, London, W.C.1 (May 10).

ASSISTANT (Grade B) TO TEACH PHYSICS, MATHEMATICS AND CHEMISTRY to Advanced Level G.C.E.—The Principal, North-West Kent College of Technology, Miskin Road, Dartford.

CLINICAL BIOCHEMIST, to assist in research into metabolic changes accompanying burns—The Group Secretary, Booth Hall Children's Hospital, Blackley, Manchester 9.

DEMONSTRATOR IN THE PLANT PHYSIOLOGY DEPARTMENT, for teaching and to carry out research—The Professor of Plant Physiology, Imperial College of Science and Technology, Prince Consort Road, London, S.W.7.

LECTURER IN BOTANY—The Secretary, Queen Elizabeth College (University of London), Campden Hill Road, London, W.8.

LECTURER IN CHEMISTRY; a LECTURER IN PHYSICS; and Grade B ASSISTANTS IN CHEMISTRY, PHYSICS AND MATHEMATICS—The Principal, Reading Technical College, King's Road, Reading.

LECTURER (with proved research ability in physical metallurgy or in metal physics) IN PHYSICAL METALLURGY—Prof. J. G. Ball, Metallurgy Department, Imperial College of Science and Technology, London, S.W.7.

MASTER TO TEACH MATHEMATICS up to Scholarship Level—The Headmaster, Cheltenham College.

MATHEMATICS MASTER, principally to share Sixth Form teaching up to Scholarship Standard with some work in the Middle School—The Head Master, University College School, Frognal, Hampstead, London, N.W.3.

RESEARCH ASSISTANT (science graduate, preferably with previous experience in serology and blood-group studies), to carry out experimental work in animal blood-groups—The Administrative Secretary, School of Veterinary Medicine, The University, Madingley Road, Cambridge.

SCIENTIFIC ASSISTANT (ABSTRACTOR) (with a degree in agriculture or natural science and a knowledge of languages)—The Director, Commonwealth Bureau of Pastures and Field Crops, Hurley, Berkshire.

SCIENTIFIC OFFICER (PETROLOGIST) (with a first- or good second-class honours degree in geology and at least five years postgraduate experience in petrology) IN THE GEOLOGICAL SURVEY DEPARTMENT, Federation of Nigeria, for duties which will include petrological and mineralogical work in the Geological Survey Laboratories, with good opportunities for research—The Director of Recruitment, Colonial Office, London, S.W.1, quoting BCD.105/14/06.

SENIOR ASSISTANT IN AGRICULTURAL CHEMISTRY or LECTURER (Assistant, Grade II) IN AGRICULTURAL CHEMISTRY—The Clerk to the Governors, Essex Institute of Agriculture, Writtle, near Chelmsford, Essex.

SENIOR LECTURER IN ELECTRICAL POWER (ELECTRICITY SUPPLY); a SENIOR LECTURER IN ELECTRICAL MACHINES; a LECTURER IN ELECTRONICS (ELECTRICAL COMPUTING); a LECTURER IN ELECTRICAL ENGINEERING (UTILIZATION); and an ASSISTANT LECTURER IN ELECTRONICS—The Secretary, Northampton College of Advanced Technology, St. John Street, London, E.C.1.

SENIOR LECTURER (well qualified physicist and preferably with some experience of the application of physics in industry) IN PHYSICS—The Registrar, Bradford Institute of Technology, Bradford 7.

VICE-PRINCIPAL (with high academic qualifications, responsible experience in administration and teaching, and preferably some industrial experience), to assist in the general administration of the College—The Principal, Cambridgeshire Technical College and School of Art, Collier Road, Cambridge.

REPORTS and other PUBLICATIONS

(not included in the monthly Books Supplement)

Great Britain and Ireland

Electrified Production, No. 1 (November, 1958). A quarterly illustrated newsletter. Pp. 4. (London: Electrical Development Association, 1958.) [191

British Council. 1959–60 Scholarships Abroad: Scholarships offered to British Students by Foreign Governments and Universities. Pp. iii+37. (London: British Council, 1959.) [191

Department of Scientific and Industrial Research: Lending Library Unit. L. L. U. Translations Bulletin, January 1959. Pp. iii+70. Published monthly. Annual subscription: 53*s.* including postage. Single issues 4*s.* (London: H.M. Stationery Office, 1959.) [191

Ministry of Agriculture, Fisheries and Food. Fishery Investigations, Series 2, Vol. 21, No. 8: An Account of the Fishing Gear of England and Wales. By F. M. David. Pp. v+165. (London: H.M. Stationery Office, 1958.) 35*s.* net. [191

Building Research Station Digest No. 117: Condensation and the Design of Factory Roofs. Pp. 4. (London: H.M. Stationery Office, 1959.) 3*d.* [261

Imperial College of Science and Technology. Code of Practice Against Radiation Hazards. Revised edition. Pp. iii+27. (London: Imperial College of Science and Technology, University of London, 1958.) [261

Ministry of Supply. Reports on Plastics in the Tropics. No. 10: Synthetic Resin Bonded Laminated Sheet. Pp. 49. (London: H.M. Stationery Office, 1958.) 6*s.* net. [261

Philosophical Transactions of the Royal Society of London. Series B: Biological Sciences. No. 689, Vol. 242 (22 January 1959): Studies of the Post-Glacial History of British Vegetation. By H. Godwin. 14: Late-Glacial Deposits at Moss Lake, Liverpool. Pp. 127–149+plates 3 and 4. 10*s.* No. 690, Vol. 242 (22 January 1959): A Study of the Development of the Head and Pharynx of the Larval Urodele *Hynobius* and Its Bearing on the Evolution of the Vertebrate Head. By H. Fox. Pp. 151–205+plates 5–7. 27*s.* 6*d.* (London: Royal Society, 1959.) [261

Forestry Commission. Forest Record No. 38: Design of Poplar Experiments. By J. N. R. Jeffers. Pp. 19. (London: H.M. Stationery Office, 1958.) 1*s.* 9*d.* [261

Ministry of Education Pamphlet No. 36: Teaching Mathematics in Secondary Schools. Pp. viii+154. (London: H.M. Stationery Office, 1958.) 6*s.* net. [261

Glasshouse Crops Research Institute. Annual Report 1957. Pp. 161. (Littlehampton: Glasshouse Crops Research Institute, 1958.) 10*s.* [261

Department of Scientific and Industrial Research: Hydraulics Research Station. Hydraulics Research Paper No. 1: Resistance of Fluids Flowing in Channels and Pipes. By Peter Ackers. Pp. iv+39. 8*s.* 6*d.* net. Hydraulics Research Paper No. 2: Charts for the Hydraulic Design of Channels and Pipes. By Peter Ackers. Pp. iv+46. 12*s.* net. (London: H.M. Stationery Office, 1958.) [261

Mathematics Before Newton. By Prof. A. R. Manwell. (Inaugural Lecture given in the University College of Rhodesia and Nyasaland.) Pp. 57. (London: Oxford University Press, 1959.) 4*s.* net. [281

Department of Scientific and Industrial Research: Building Research Station. National Building Studies—Research Paper No. 27: Noise in Three Groups of Flats with Different Floor Insulations. By P. G. Gray, Ann Cartwright and P. H. Parkin. Pp. iv+61. (London: H.M. Stationery Office, 1958.) 4*s.* net. [281

Bulletin of the British Museum (Natural History). Entomology. Vol. 7, No. 8: New or Little Known Butterflies from Malaya. By Lt.-Col. J. N. Eliot. Pp. 369–391+plate 10. 8*s.* Zoology. Vol. 5, No. 6: Ear Plug Laminations in Relation to the Age Composition of a Population of Fin Whales (*Balaenoptera physalus*). By P. E. Purves and M. D. Mountford. Pp. 123–161+plates 5 and 6. 20*s.* (London: British Museum (Natural History), 1959.) [291

The Engineer Buyers Guide 1959. Pp. 960. (London: *The Engineer*, 1959.) 7*s.* 6*d.* [301

Imperial College of Science and Technology. Post graduate Courses, 1959–60. Pp. xii+111. (London: Imperial College of Science and Technology, University of London, 1959.) [301

British Hat and Allied Feltmakers Research Association. Eleventh Annual Report of the Director of Research for the year ended August, 1958. Pp. 20. (Manchester: British Hat and Allied Feltmakers Research Association, 1959.) [301

University of Birmingham. Report of the Vice-Chancellor and Principal for the calendar year 1958. Pp. 26. Accounts for the year ended 31st July, 1958. Pp. 36. Report of the Proceedings of the Council of the University for the year ended 31st December 1958. Pp. 18. (Birmingham: The University, 1958 and 1959.) [301

Philosophical Transactions of the Royal Society of London. Series B: Biological Sciences. No. 961, Vol. 242 (29 January 1959): A New Armoured Amphibian from the Upper Permian of East Africa. By A. L. Panchen. Pp. 207–281. (London: Royal Society, 1959.) 25*s.* [301

Other Countries

Museum of Comparative Zoology at Harvard College. Breviora. No. 97 (October 27, 1958): Fusion of Cervical Vertebrae in the *Erethizontidae* and *Dinomyidae*. By Clayton E. Ray. Pp. 11. No. 98 (December 12, 1958): Two New Species of *Bathylagus* from the Western North Atlantic with Notes on other species. By Daniel M. Cohen. Pp. 9. No. 99 (December 19, 1958): A New Subspecies of *Chamaeleo jacksoni* Boulenger and a Key to the Species of Three-Horned Chamaeleons. By A. Stanley Rand. Pp. 8. No. 100 (December 23, 1958): On the Pineal Organ of the Tuna, *Thynnus thynnus* L. By Uno Holmgren. Pp. 5. (Cambridge, Mass.: Museum of Comparative Zoology at Harvard College, 1958.) [261

United States Department of Agriculture. Agriculture Information Bulletin No. 194: Salt Tolerance of Grasses and Forage Legumes. By Leon Bernstein. Pp. 7. (Washington, D.C.: Government Printing Office, 1958.) 5 cents. [261

Rensselaer Polytechnic Institute, Troy, New York. Annual Report, 1957–1958. Pp. 68. (Troy, New York: Rensselaer Polytechnic Institute, 1958.) [261

Regional Research Laboratory, Hyderabad. Annual Report, 1957–1958. Pp. ix+136. (Hyderabad: Regional Research Laboratory, 1958.) [261

National Research Development Corporation of India. Fourth Annual Report and Statement of Accounts for the period ending 31st March, 1958. Pp. 20. (New Delhi: National Research Development Corporation of India, 1958.) [261

Canada: Department of Mines and Technical Surveys. Geological Survey of Canada. Bulletin 43: Stratigraphy of the Lewes River Group (Triassic), Central Laberge Area, Yukon Territory. By E. T. Tozer. Pp. v+28 (3 plates). 50 cents. Bulletin 46: Contributions to Canadian Palynology. Part 1: The Use of Palynological Studies in Pleistocene Stratigraphy. Part 2: Non-glacial Deposits in the St. Lawrence Lowlands, Quebec. Part 3: Non-glacial Deposits along Missinaibi River, Ontario. By J. Terasmae. Pp. vi+35+3 plates. 50 cents. (Ottawa: Queen's Printer, 1958.) [261

Tanganyika: Department of Geological Survey. Records of the Geological Survey of Tanganyika, Vol. 5, 1955. Pp. iii+99+23 plates. Shs. 15. G.S. Map No. 1134: Manda. G.S. Map No. 1168: Tukuyu. (Dar-es-Salaam: Government Printer, 1958.) [261

Department of Agriculture, Fiji. Bulletin No. 32: Copra Driers: Principles of Copra Drying and Practical Applications. Pp. iv+36. (Suva: Government Printer, 1958.) 3*s.* [261

Conseil Permanent International pour l'Exploration de la Mer, Charlottenlund Slot, Danemark. Fiches d'Identification du Zooplancton, Nos. 71–80. Rédigé par J. H. Fraser. Pp. 38. (Copenhagen: Andr. Fred Høst & Fils, 1958.) 15.00 kr. [261

National Academy of Sciences—National Research Council, Washington. A Commentary on the Report of the United Nations Scientific Committee on the Effects of Atomic Radiation. (Committee on Pathologic Effects of Atomic Radiation, Report No. 2.) Pp. 1+5. (Publication 647.) (Washington, D.C.: National Academy of Sciences—National Research Council, 1959.) [261

Companhia de Diamentes de Angola (Diamang.) Servicos Culturais. Dundo-Lunda-Angola. Museu do Dundo. Subsidios para 1 Estudo da Biologia na Lunda. Publicacoes Culturais No. 40: Estudos Diversos (XV). Pp. 147. (Lisboa: Companhia de Diamantes de Angola, 1958.) [261

Proceedings of the Symposium on Prestressed Concrete as Applied to Buildings, held at the Central Building Research Institute, Roorke, (U.P.), India, 10th–12th February, 1958. (*Indian Construction News*, Vol. 7, No. 8). Pp. 136. (Calcutta: Technical Journals of India Private, Ltd., 1958.) [261

Berichte des Deutschen Wetterdienstes. Nr. 48 (Band 7): Untersuchungen über den Nachtlichen Energietransport und Energiehaushalt in der Bodennahen Luftschicht bei der Bildung von Strahlungsnebeln. Von Helmut Kraus. Pp. 25 (mit 9 Abbildungen und 7 Tabellen im Text und 10 Tafeln im Anhang.) (Offenbach: Deutschen Wetterdienstes, 1958.) [261

Journal of Applied Mathematics and Mechanics, Vol. 22, No. 1. Translated from the Russian. Pp. ii+202. Issued bi-monthly or corresponding to the number of original Russian issues per annum. One volume per year. Approximately 1,200 English pages. Annual subscription rate: 35 dollars; £12 10*s.* 0*d.* (New York and London: Pergamon Press, 1958.) [261

Proceedings of the California Academy of Sciences. Fourth Series. Vol. 29, No. 9: Bibliography, Cartography, Discovery, and Exploration of the Islas Revillagigedo. By Adrian F. Richards and Bayard H. Brattstrom. Pp. 315–360. Vol. 29, No. 10: A Revision of the Species of *Pandeleteius* Schönherr and *Pandeleteinus* Champion of America North of Mexico (Coleoptera: Curculionidae.) By Anne T. Howden. Pp. 361–421+2 plates. (San Francisco: California Academy of Sciences, 1959.) [261

Kungl. Tekniska Högskolans Handlingar. (Transactions of the Royal Institute of Technology, Stockholm.) Nr. 129: Investigations of the Disk-Loaded and Helical Waveguide. By Bengt T. Henoch. Pp. 84. (Stockholm: Elanders Boktryckeri Aktiebolag, 1958.) 9 kronor. [281

United States Department of the Interior: Geological Survey. Bulletin 1071-B: Geologic Reconnaissance of San Clemente Island, California. By F. H. Olmsted. Pp. iii+55–68+plate 1. 75 cents. Bulletin 1071-C: Origin of Steps on Loess-Mantled Slopes. By James C. Brice. Pp. iii+69–85+plates 2 and 3. 25 cents. Bulletin 1082-A: Zirconium and Hafnium in the Southeastern Atlantic States. By John B. Mertie, Jr. Pp. iii+28. 15 cents. Professional Paper 316-B: Interpretation of an Aeromagnetic Survey of Indiana. By John R. Henderson, Jr., and Isidore Zietz. Pp. iii+19–37+plates 4 and 5. 75 cents. (Washington, D.C.: Government Printing Office, 1958.) [281

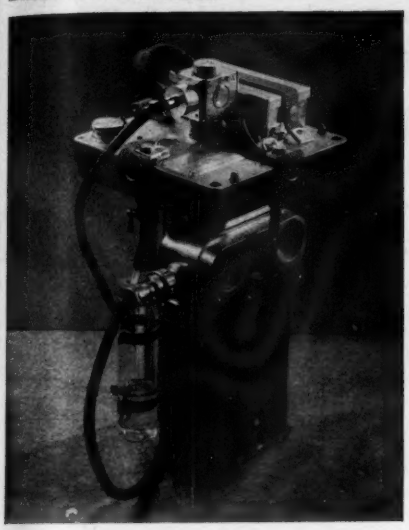
Editorial and Publishing Offices of "NATURE"
MACMILLAN & CO., LTD.,
ST. MARTIN'S STREET, LONDON, W.C.2.
Telephone Number: Whitehall 8831. Telegrams: Phusis Lesquare London

Annual subscription £7/15/–, payable in advance, postage paid to any part of the world

Advertisements only should be addressed to
T. G. Scott & Son, Ltd., 1 Clement's Inn, London, W.C.2
Telephone Number: Holborn 4743

All rights reserved. Registered as a newspaper at the General Post Office

Sampling AIRBORNE DUST with 100% efficiency



The Thermal Precipitator enables organic or inorganic dust particles to be collected with an efficiency approaching 100 per cent for particles below 10μ.

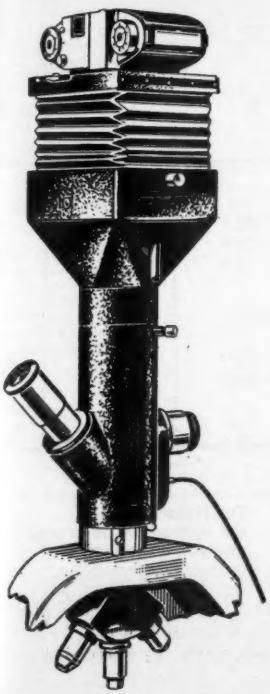
It is compact, light in weight and adaptable to awkward sampling positions.

A detailed description of the various forms in which it is available will be found in leaflet No. 804.

CASELLA LONDON **THERMAL PRECIPITATOR**

C. F. CASELLA & CO. LTD.,
Regent House, Fitzroy Square, London, W.1 Tel. EUSton 3944

Members of the Scientific Instrument Manufacturers' Association of Great Britain, and the British Scientific Instrument Research Association



In the Infra-red, Visible or Ultra-violet range to join up at once a microscope

with

a photographic camera	a Tomophotometer
a cine camera	a Spectrophotometer
a television camera	an Hematelec
a projection screen	a Motilimeter

with the possibility simultaneously of

OBSERVATION

and automatic Chrono-release of the magnetic shutter with the *Chronophotometer*, use the:

-e-u-r-o-p-é-l-e-c→

TRINOCULAR TUBUS

Les Clayes-sous-Bois (S.-&-O.)
FRANCE Tél.: VAL D'OR 17–10

Semiconductors

COMPUTER TRANSISTORS

The Semiconductors range of Computer Transistors, designed and tested to the special requirements of computer engineers, is the key to a new order of computer speed and reliability. Overall reliability is further increased by making possible a substantial reduction in the number of associated components.

The two types of Silicon Alloy Transistor shortly going into production will make it possible to extend this high-speed computer performance into **ambient** temperatures well above 100°C. **Samples are available now.**

	TYPE	DESCRIPTION	RISE TIME millimicroseconds	Vc max	Ic max
HIGH-SPEED LOW-LEVEL SWITCHING GERMANIUM	SB 344 SB 345	General purpose transistors for conventional logic circuits.	50	5v	5mA
	SB 240	Designed for directly coupled circuits. Controlled input, saturation and hole storage characteristics.	30	6v	15mA
	MA 393	High gain transistor for high-speed driving of parallel circuits.	30	6v	50mA
	2N 501	Ultra-high speed transistor with controlled input and saturation characteristics.	10	12v	50mA
HIGH-SPEED LOW-LEVEL SWITCHING SILICON	SA 495	General purpose 10Mc/s transistor for conventional logic circuits.	100	25v	50mA
	SA 496	15Mc/s transistor for directly coupled circuits. Saturation resistance typically 10 ohms. Controlled input and hole storage characteristics.	80	10v	50mA
CORE DRIVING GERMANIUM	2 N 597 2 N 598 2 N 599	min f_α 3Mc/s min f_α 5Mc/s min f_α 12Mc/s 250 mW high frequency alloy transistors with high gain and low saturation resistance	400 * 250 * 100 *	20v 20v 20v	400mA 400mA 400mA
	2 N 600 2 N 601	min f_α 5Mc/s min f_α 12Mc/s 750 mW versions of 2 N 598 and 2 N 599. Peak current 3 amps.	250 * 100 *	20v 20v	400mA 400mA

* rise time to 400mA

Semiconductors Limited

Full technical details and applications assistance available on request.

CHENEY MANOR
SWINDON · WILTS
TELEPHONE: SWINDON 6421/7

SC10

3700

Eastman Organic Chemicals —and how to get hold of them

Scientific workers everywhere have come to rely on the great stock of some 3700 Eastman Organic Chemicals. To be able to order uncommon compounds or compounds of uncommon purity from a single reliable source is often far more economical than to make them in your own laboratory or to search the chemical commodity markets for them.

To take advantage of this convenience in Great Britain, Kodak Limited, Kirkby, Liverpool relieves you of the import formalities involved in ordering directly from the U.S.A. They welcome questions on availabilities and prices. They can furnish literature abstracts on many analytical procedures with Eastman Organic Chemicals.

And in countries other than Britain, Eastman Organic Chemicals can be ordered from the firms listed below.

AUSTRALIA
H. B. Selby & Co. Pty. Ltd.
254A George Street
Sydney, N.S.W.

H. B. Selby & Co. Pty. Ltd.
393 Swanston Street
P. O. Box 409G
Melbourne, C.1

H. B. Selby & Co. Pty. Ltd.
Box 606J, G.P.O.
Brisbane, Queensland

AUSTRIA
Heilmittelwerke Wien
G.m.b.H.
III/40, Rennweg 12
Vienna

W. J. Rohrbecks Nachf.
Wehrgasse 18
Vienna V

BELGIUM
Analis, S. A.
14, Rue Dewez
Namur

DENMARK
H. Struers Chemiske
Laboratorium
38, Skindergade
Copenhagen K

FINLAND
G. W. Berg & Co.
Fabiansgatan 14
Helsinki

Havulinna Oy
P. O. Box 468
Helsinki

FRANCE
Touzart & Matignon
3, Rue Amyot
Paris Ve

GERMANY
Serva-Entwicklungslabor
Hausserstrasse 45
Heidelberg

HOLLAND
N. V. Holland Indonesia
Agenturen Mij.

HIAM
139 De Ruyterkade
Amsterdam C

INDIA
The Andhra Scientific Co., Ltd.
4, Blacker's Road, Mount Road
Madras

Raj-Der-Kar & Co.
Commissariat Building
Hornby Road, Fort
Bombay

INDONESIA
N. V. Chemicalienhandel
Rathkamp and Co.
18 Djalan Madja Pahit
Djakarta

JAPAN
Asano Bussan Company
New Kaijo Building
6 Marunouchi I-Chome,
Chiyoda-ku
Tokyo

NEW ZEALAND
Kempthorne, Prosser and Co's.
New Zealand Drug Co., Ltd.
P. O. Box 1495
Wellington, C.1

Kempthorne, Prosser and Co's.
New Zealand Drug Co., Ltd.
P. O. Box 319
Dunedin, C.1

NORWAY
Nerliens Kemisk-Tekniske
Aktieselskap
Tollbodgt. 32
Oslo

PORTUGAL
Soquimica, Sociedade de
Representacoes de
Quimica, Lda.
Rua dos Correeiros, 113-3°
Lisbon

SOUTH AFRICA
Kodak (South Africa) (Pty.)
Limited
"Kodak House"
45 Shortmarket Street
Cape Town

SWEDEN
Rudolph Grave A/B
Box 3082
Stockholm 3

SWITZERLAND
Dr. Bender & Dr. Hobein AG.
Riedtlistrasse 15a
Zurich 6

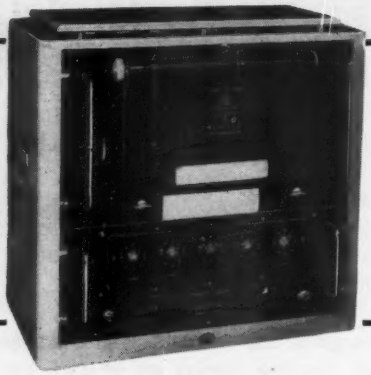
DPi

Distillation Products Industries
Eastman Organic Chemicals Department
Rochester 3, N. Y., U. S. A.
(Division of Eastman Kodak Company)

DIGITAL PRINT-OUT

FAST *

RELIABLE *



* AUTOMATIC

* ROBUST

FOR ALL FORMS OF REPETITIVE COUNTING

FASTER COUNTING ! LOWER PRICE !

The Labgear Printing Counter D.4123 is a completely self-contained counter/printer capable of counting up to 20 Kc/s and printing the answer in less than 2 seconds.

It may be integrated with existing equipment to act either as a Timer or Counter, printing either in " time-per-unit-counts " or " counts-in-unit-time."

For automatic control of a repetitive counting cycle the new Count Programme Unit D.4127 is now available. The unit permits the selection of a desired counting period followed by an optional waiting period to cover the operating time of associated equipment such as Sample Changers, Chromatogram Scanners, etc.

Please write for further details to:

Labgear Ltd.

WILLOW PLACE · CAMBRIDGE.

Telephone: 2494. Telegrams: "Labgear, Cambridge."

New! All-in-one
SCALER 1700

Look at these Features!

1. Fast Scaler with 9 pre-set count positions.
2. Electronic Timer with 9 pre-set time positions.
3. Triple range ratemeter with long and short time constants.
4. Single Channel Pulse Height Analyser.
5. 250 to 2000V stabilised H.V. supply.
6. Linear Amplifier, sensitivity 5mV – 50V.
7. Every equipment has 100 hour "Soak Test".
8. "Chimney" construction reduces internal heating.
9. Conservative rating of all components.
10. Sound mechanical engineering.
11. Immediately replaceable plug-in printed circuit boards for more than 80% of the equipment.
12. Quick release top and bottom covers give complete access to interior.
13. More than 90% of tubes internationally available.
14. Operates directly with most types of radiation detectors.
15. Power supplies for external Head Amplifier or Quench Unit.
16. Will operate printing register.
17. Connection for count rate recorder.
18. Tilt-up stand fitted for convenient viewing.
19. Main functions push button selected.
20. Converts Easily to Rack Mounting Unit.
21. Recommended spares kit available.

Write for detailed specification:

I D L NUCLEONIC EQUIPMENT

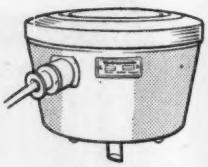
ISOTOPE DEVELOPMENTS LTD.

BEENHAM GRANGE, ALDERMASTON WHARF, NR. READING, BERKS. Tel: Woolhampton 451
LONDON OFFICE
120 Moorgate, London, E.C.2. Tel: Met. 9641.

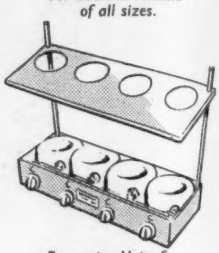
There are many ISOMANTLES for the Laboratory . . .

One Multisize Isomantle takes several flask sizes.

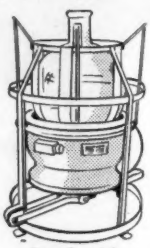
For Semi-micro analysis.



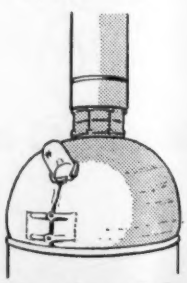
For Buchner Funnels of all sizes.



Extraction Units for Soxhlet and Kjeldahl work



Drop Stand for exothermal reactions.



Bottom and top mantles for all flasks up to 200L capacity.

Can we solve your heating problem . . . . ?

The display of electric heating mantles is representative of the variety of laboratory heaters we offer. For special heating problems we make Isomantles to individual requirements. We have lately doubled the production space of our modern factory and can serve you better than ever.

Send for catalogue LM on laboratory mantles and the latest Plant Catalogue PLT/58 fully documenting Electric Surface Heaters for pipe lines, columns, and vessels.

ISOPAD LTD ELECTRIC SURFACE HEATERS

ISOPAD LTD., BARNET BY-PASS, BOREHAM WOOD, HERTS.
Telephone: ELStree 2817/9 Grams: Isopad, Borehamwood

Are you a boffin?

No, I ain't. And just you stop fiddlin' —
that's a very valuable piece of 'igh vacuum equipment.

So I can see . . . maintained, I trust, at maximum efficiency by the use of Apiezon oils, waxes and greases?

'Op it — or you'll be in a 'igh vacuum before
you can say 'Shell Chemicals'.

SHELL CHEMICAL COMPANY LIMITED
In association with Petrochemicals Limited and Styrene Products Limited

Divisional Offices:	LONDON	Norman House, 105-9, Strand, W.C.2. Tel: TEMple Bar 4455.
	MANCHESTER	144-6, Deansgate. Tel: Deansgate 2411.
	BIRMINGHAM	14-20, Corporation Street, 2. Tel: Midland 6954.
	GLASGOW	124, St. Vincent Street, C.2. Tel: Central 9561.
	BELFAST	16-20, Rosemary Street. Tel: Belfast 26094.
	DUBLIN	33-34, Westmoreland Street. Tel: Dublin 72114.

APIEZON *is a registered trade mark.*

OC.A3

Getting in touch with

ASSOCIATED LEAD

usually leads to better things

No matter how you do it, no matter what your particular industrial need, getting in touch with Associated Lead is bound to lead to better things—better products, better processes—for you and your industry.

Associated Lead Manufacturers Limited is a single company specialising in the manufacture and supply of lead and antimony in all their many forms; alloys; pure metals; chemicals and pigments.

ASSOCIATED LEAD MANUFACTURERS LIMITED CLEMENTS HOUSE, 14 GRESHAM STREET, LONDON, E.C.2. CRESCENT HOUSE, NEWCASTLE. LEAD WORKS LANE, CHESTER.

Export Enquiries to: Associated Lead Manufacturers Export Co. Ltd., Clements House, 14 Gresham Street, London, E.C.2

ADVANCES IN

Biological and Medical Physics

Edited by CORNELIUS A. TOBIAS and JOHN H. LAWRENCE, *University of California, Berkeley*

VOLUME VI

February 1959, 639 pp., illus., 118s.

CONTENTS :

RICHARD P. DURBIN, PETER F. CURRAN, and A. K. SOLOMON, Ion and Water Transport in Stomach and Intestine (pp. 1–36)
ERIK ZEUTHEN, Artificial and Induced Periodicity in Living Cells (pp. 37–73)
HERBERT MARCOVICH and RAYMOND LATARJET, Radiobiological Aspects of the Induction of Lysogenic Bacteria to Produce Phage with X-Ray, Gamma-Ray, and Ultraviolet Radiations (pp. 75–94)
BO THORELL, Cell Studies with Microspectrography (pp. 95–119)
O. C. A. SCOTT, Some Aspects of the Effect of Ionizing Radiation on Tumors in Experimental Animals (pp. 121–173)
CHARLES L. DUNHAM, Fallout from Nuclear Weapons Tests (pp. 175–199)
B. JACOBSON and R. STUART MACKAY, Radiological Contrast Enhancing Methods (pp. 201–261)
W. H. FREYGANG, JR. and LOUIS SOKOLOFF, Quantitative Measurement of Regional Circulation in the Central Nervous System by the Use of Radioactive Inert Gas (pp. 263–279)
WILLIAM J. FRY, Intense Ultrasound in Investigations of the Central Nervous System (pp. 281–348)
SOLOMON A. BERSON and ROSALYN S. YALOW, Isotopic Tracers in the Study of Diabetes (pp. 349–430)
E. PETER GEIDUSCHEK and ALFRED HOLTZER, Application of Light Scattering to Biological Systems: Deoxyribonucleic Acid and the Muscle Proteins (pp. 431–551)
PAUL HOWARD-FLANDERS, Physical and Chemical Mechanisms in the Injury of Cells by Ionizing Radiations (pp. 553–603)
AUTHOR INDEX—SUBJECT INDEX (pp. 605–639).

Proceedings of the International Congress of

Radiation Research

Burlington, Vermont, August 11–15, 1958

SUPPLEMENT 1 TO RADIATION RESEARCH

Edited by DOUGLAS E. SMITH, *Argonne National Laboratory, Lemont, Illinois*

February 1959, paper bound, 582 pp., illus., 52s.

"Here many of the world's most prominent research workers in radiation physics, biology, and chemistry review for scientists in their own and other disciplines the present status of knowledge and the probable future directions of study in most of the significant areas of radiation research. The first symposium deals in a general manner with the status of radiation chemistry, physics, and biology. The remaining symposia are concerned with specific subjects which are of great interest at the present time or which promise to be of increasing significance in the future. In addition to being comprehensive treatises, many of the papers contain new data of fundamental interest." *From the Editor's Preface.*

Biophysical Chemistry

By JOHN T. EDSALL, *Harvard University* and JEFFRIES WYMAN, *UNESCO, Cairo, Egypt*

Volume 1 : Thermodynamics, Electrostatics, and the Biological Significance of the Properties of Matter

1958, 699 pp., illus., 100s.

REVIEW :

"The book gives a very lucid, authoritative, detailed, and thorough account of some of the most important physical principles that are now being used in physical chemical research on biologically important substances, especially in the protein field." —*The American Scientist*

Detailed leaflets available upon request

ACADEMIC PRESS, New York and London

111 Fifth Avenue, New York 3, New York

40 Pall Mall, London, S.W.1

British Sales Office : Academic Books Ltd., 129, Queensway, London, W.2

P.V.S. REAGENTS

H&W Regd.

Hopkin & Williams Ltd., have now added Benzoic acid to the range of P.V.S. reagents. Benzoic acid has been recommended as an alkalimetric standard in volumetric analysis by a number of workers and has also been widely employed as a standard substance in calorimetry. For both purposes, purification by fractional freezing has been described and the efficiency of the process has been thoroughly tested.

Zone refining techniques have received much attention in recent years and their development has made it possible to apply the principle of fractional freezing in a new and particularly effective way.

Benzoic acid is ideally suited to this "zone-melting" purification process and P.V.S. brand Benzoic acid results from the application of zone-purification to Benzoic acid ANALAR.

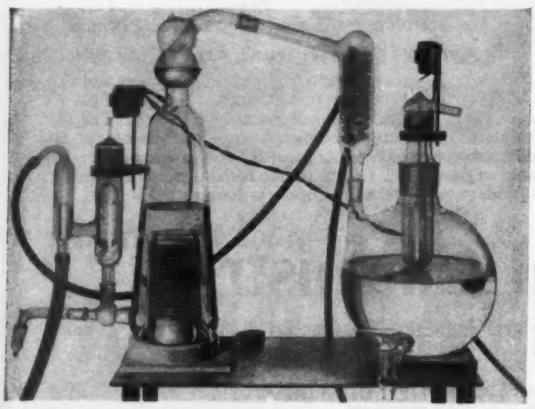
Zone melting apparatus manufactured by Baird & Tatlock (London) Ltd., in use in the H. & W. Chemical Laboratories for the preparation of P.V.S. Benzoic acid.

A technical leaflet on P.V.S. Reagents, Purified for Volumetric Standardisation, will be sent on request.

HOPKIN & WILLIAMS Limited

CHADWELL HEATH · ESSEX · ENGLAND

Branches in LONDON · MANCHESTER · GLASGOW · Agents throughout the U.K. and all over the world



This unique water still is in use in a number of research establishments and hospitals where water of the highest purity is essential

PRICE, complete with heater and all electrical equipment 230 volt (a.c. only)—**£25 - 10 - 0**

Inclusive of carriage and packing in U.K.

Obtainable ONLY from

L. V. D. SCORAH, M.Sc.

(Manufacturer of the "SCORAH" Blowpipe)

44 NORTHFIELD ROAD, KINGS NORTON, BIRMINGHAM, 30. KINGS NORTON 1885

The SCORAH Automatic Electric all glass WATER STILL (patented)

Automatic Can be left on without attention. Heater current cuts off if water supply is interrupted, or inadequate or forgotten. When receiver (5 litres capacity) is full, current cuts off. When distilled water is drawn from receiver, the still resumes operation until receiver is refilled.

Purity Electrostatically charged condenser droplets can pick up fumes, dust and air-borne organisms from the laboratory atmosphere. The design of the receiver vessel ensures absence of such contamination.

Efficiency Heater of Scorah design and manufacture, consumption 1,700 watts, output 2.4 litres per hour (the full theoretical yield). Cost 3½d. per gallon at 1d. per unit.

Safety The heating element is out of contact with the feed water, thus eliminating danger from "live" water supply or electrolytic effects or "burn out".

Assembly No retort stands or clamps are required. The 2½-in. diameter ball joint gives a strainless set-up. Outlet cap on boiler for quick periodical drain-off of sediment. The still may be installed on a shelf or platform about 1 ft. above bench level near a sink and enclosed in a transparent plastic cover to keep out dust.

Phoenix heat-resisting glass. Interchangeable ground glass joints.

TWO WAYS OF OBTAINING DISTILLED WATER

THE OLD

High cost — increased transport charges — bulk storage and inconvenience.

THE NEW

The C.T.P. 'Deminrolit' plant above produces approximately 300 gallons hourly of distilled quality water without using heat or steam. Operating by Ion Exchange, C.T.P. 'Deminrolit' plants occupy little space, are simple to operate and ensure a demineralised water of consistent quality.

PERMUTIT 'DEMINROLIT'

THE PERMUTIT COMPANY LIMITED, Dept. V.H.290, Permutit House, Gunnersbury Avenue, London, W.4. Telephone CHIswick 6431

Statistics

STATISTICAL TABLES FOR BIOLOGICAL, AGRICULTURAL AND MEDICAL RESEARCH

–5th Edition

Sir Ronald A. Fisher

Frank Yates

A number of new tables have been included in this new edition of a standard reference work to extend its already wide range of usefulness. 24s. net.

STATISTICAL METHODS IN RESEARCH AND PRODUCTION

Edited by Owen L. Davies

Previous editions have established this as a standard handbook for scientific and industrial workers. It is written by a team of chemists, statisticians, engineers, and physicists who have had considerable experience in research and process work in the chemical industry. Revision for this new edition has been extensive.

Published for Imperial Chemical Industries Ltd.

Third Edition 45s. net.

THE DESIGN AND ANALYSIS OF INDUSTRIAL EXPERIMENTS

Edited by Owen L. Davies

"Dr. Davies and his colleagues at the I.C.I. have produced an authoritative account of the statistical aspects of the design and analysis of industrial experiments. Modern developments such as fractional replication and the work of Box and Wilson on the determination of optimum conditions are discussed thoroughly and, in fact, a substantial part of the book is concerned with advanced designs."

Journal of the Royal Statistical Society.

Published for Imperial Chemical Industries Ltd.

Second Edition 63s. net.

Send for Statistics List to :

Oliver & Boyd

Tweeddale Court, Edinburgh 1

...A complete PRINTING SERVICE for Scientific and Learned Societies is available in the City of Oxford at ...

THE ALDEN PRESS (OXFORD) Ltd

BINSEY LANE PHONE OXFORD 48475/6

Our Consultant will be glad to call and advise on Typography or Illustration and suggest the most economical process to use, or to take instructions for printing your Papers, Proceedings, Journals, etc., and for distributing them eventually to your Members.

WM. DAWSON & SONS LTD.

ANTIQUARIAN SCIENTIFIC PERIODICALS & BOOKS

Complete libraries purchased

16 PALL MALL • LONDON • S.W.1

BRASS • COPPER • DURAL • ALUMINIUM • BRONZE •

ROD, BAR, SHEET, TUBE, STRIP, WIRE

3,000 STANDARD STOCK SIZES

No Quantity too small • List on application

H. ROLLET & CO., LTD.

6, CHESHAM PLACE, LONDON, S.W.1. SLOane 3463

Also at: LIVERPOOL, LEEDS, MANCHESTER, BIRMINGHAM

THE WORLD'S GREATEST BOOKSHOP

FOYLES

+ FOR BOOKS +

"Your customers are as fascinating as your books! In half-an-hour at Foyles you can see people from almost every country in the world—people of every colour, every race, every nationality. It is a wonderful bookshop."

—A Member of Parliament

TRAVEL BUREAU NOW OPEN!

Road, Rail, Sea and Air Travel
Holiday Tours and Cruises

119-125 CHARING CROSS ROAD
LONDON WC2

Gerrard 5660 (20 lines) ★ *Open 9–6 (Mon. & Thur. 9–7)*

Two minutes from Tottenham Court Road Station

Principles of Automatic Controls

FLOYD E. NIXON

Written for the practising engineer, whether aeronautical, electrical, or mechanical, this comprehensive book on the field of automatic controls covers all the most recent methods used in control system design. It is the first book in the control analysis field which includes transient analysis, utilizations of automatic computers and numerical integration, as well as frequency response analysis methods.

With diagrams 30s

Theoretical Aerodynamics

Third Edition

L. M. MILNE-THOMSON, C.B.E.

The third edition contains a fifty-page chapter on sweptback and delta wings, in which the various cases of the linearised problem of the supersonic delta wing are elucidated in detail by a consistent simple method. *40s*

MACMILLAN BOOKS

Matter, Earth and Sky

GEORGE GAMOW

AUTHOR OF *The Creation of the Universe*
The Birth and Death of the Sun
The Biography of the Earth
One, Two, Three . . . Infinity

This lively book by the Professor of Physics at the University of Colorado deals with physics, chemistry, astronomy, geology, and meteorology, under three heads: Matter and Energy, Microcosm and Macrocosm.

Well illustrated 50s

The Earliest Geological Treatise (1667)

NICOLAUS STENO

Nicolaus Steno's Latin treatise entitled *Elementorum myologiae specimen . . . Canis Carchariae dissectum caput . . .*, which inaugurated geology as a science, is translated page-by-page by Dr. Axel Garboe, a leading authority on Steno's geological works. In addition, this little book includes a brief biography of Steno, a bibliography and notes relating to the translation.

4 plates 15s

ST MARTIN'S STREET · LONDON W C 2

More Scintillators from N.&T.

Scintillators in five forms are now available from Nash and Thompson Ltd:

CRYSTALS
Anthracene, Stilbene, Diphenylacetylene, in discs and cylinders.

PLASTICS
N.11 and N.11—X-ray, high sensitivity, high transmission *polyvinyl toluene based.*

LIQUIDS
Ready made, sealed in glass containers to your specification, or as scintipaks.

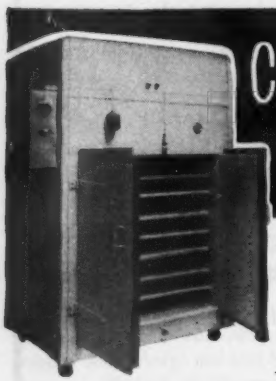
SCINTIPAKS
Accurately mixed dry constituents sealed *in polythene* envelopes, ready for dissolving in a suitable solvent as required.

POWDERS
Scintillation purity chemicals for *crystal growing* experiments, and the manufacture of special scintillators.

Write or telephone for full information **Nash and Thompson** *LIMITED*

OAKCROFT ROAD · CHESSINGTON · SURREY · ENGLAND · ELMBRIDGE 5252

WHG/NT61



CONTROLLED DRYING

The Unitherm Drier conforms to strict laboratory needs and has been designed to provide rapid, uniform drying of approximately 100 trays of 400 gm. capacity. Working on the principle of a coupled heating and ventilating system, the Unitherm has been carefully tested under working conditions up to temperatures of 105° C.

Let us send you laboratory test data and full details.

BIRMINGHAM & BLACKBURN
CONSTRUCTION CO. LTD.

Armoury Close, Bordesley Green, Birmingham 9
and at George Street West, Blackburn

"GURR'S" *is the Registered Trade Mark of*
GEORGE T. GURR LTD.

Since 1915 **"GURR'S"** brand of **MICROSCOPICAL STAINS** and Reagents has become world-famous.
If you want this world-famous brand, specify **"GURR'S"** and refuse any other.

Ask for catalogue F8
GEORGE T. GURR LTD,
136-138 NEW KINGS ROAD, LONDON, S.W.6

SPICER'S ZIRCONITE
MACHINABLE REFRACTORY
• SOLVES A LOT OF PROBLEMS
• SAVES A LOT OF TIME
W. & C. Spicer Ltd., The Grange, Kingham, Oxon.
TELEPHONE: KINGHAM 307

MANSFIELD OIL-GAS PLANT FOR LABORATORIES' GAS SUPPLY
• *Reliable* • *Simple to Operate* • *Safe*

Provides a gas supply at a constant calorific value of 1,350 B.T.U.'s per cu. ft. produced from Light Diesel Oil, Gas Oil, Paraffin, or other suitable oils available at low cost.
Enables the efficient use of a full range of modern gas burning appliances in any part of the world. Ideal for glass blowing and gives perfect oxidising or reducing flames with ordinary atmospheric burners.
For full particulars send details of estimated number of burners to be used.

MANSFIELD & SONS LTD.
62 HAMILTON SQUARE, BIRKENHEAD

QUARTZ GLASS

TRANSPARENT

TUBING, ROD AND APPARATUS
TO SPECIFICATION

We also manufacture :

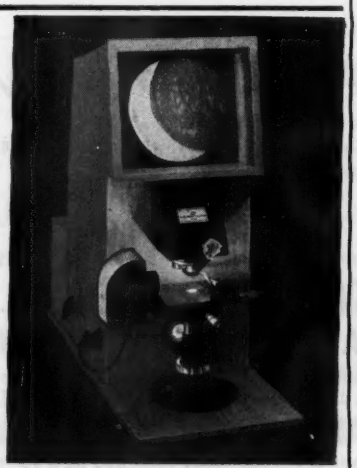
Boats, Crucibles, Ground Joints, Ball Joints, Wool, Stopcocks, Distilling Apparatus and all other Standard Laboratory items

from

KAREL HACKL
463 HARROW ROAD,
LONDON, W.10

Telephones :
LADBROKE 6496–7 LADBROKE 7254

INSPECTION
by
PROJECTION
with
Enbeeco Profile Projectors



All models can now be supplied with surface illumination attachment, which makes our instruments very versatile.

MODELS :
Mark III Magnifications : × 10, × 15.
Mark IIIA Magnifications : × 10, × 15, × 20.
Series II Magnifications : × 25, × 50.
Series IIA Magnifications : × 25, × 50, × 100.
Series IIB Wide Field, Magnifications : × 10, × 20.

For inspection by Projection invest in the economically priced Profile Projectors manufactured by :

Newbold & Bulford Ltd
Manufacturers and Exporters of Scientific Instruments
ENBEECO HOUSE, ROGER ST., GRAY'S INN RD., W.C.1
TELEPHONE : CHA 5614 (3 lines)

automation *in* photographic recording

The Shackman Autocamera is a recording instrument designed to cover a wide field in industrial and scientific work where the automatic production of micro-films is required. It is a precision instrument suitable for all purposes where long periods of visual observation and manual recording are impracticable, such as Oscilloscope Recording, Process Timing, Photomicrography and Instrument Recording. It can be fully automatic in its operation, requiring only a short single electrical impulse to operate the shutter and transport the film. A full range of accessories is available including control units and intervalometers. The Autocamera is adaptable also for industrial photography, stereoscopy, document copying and many other special applications.

shackman

Full information can be obtained from
D. Shackman & Sons,
Chesham, Bucks.
Tel : Chesham 8109 *and* 8690.

SPRAY DRYERS

—backed by 25 years' experience

For production of animal, vegetable and chemical products of all kinds.

350 industrial and 220 laboratory N.A. Spray Dryers are in operation throughout the world.

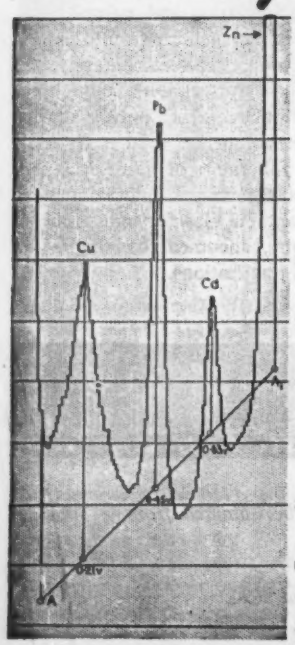
Sole Agents for the British Isles :

CORNWELL PRODUCTS LTD.
232 Great Portland Street,
LONDON, W.1
Tel. EUSTON 5897

NIRO ATOMIZER LTD 12 Aurehojvej-Hellerup COPENHAGEN-DENMARK

* COPPER · LEAD · CADMIUM .... with ZINC

How long would it take to analyse



by CONVENTIONAL METHODS, a solution having the following metals present —

COPPER - -	3 p.p.m.	CADMIUM - -	2 p.p.m.
LEAD - - -	7 p.p.m.	ZINC -	200,000 p.p.m. ?

These Square Wave Polarograms recorded by the

MERVYN-HARWELL
SQUARE WAVE POLAROGRAPH Mk. III

are reproduced here to show the identification of these metals, in these proportions, in solution. Note the high ratio of Zn to Cd., without interference. The peaks are identified by the automatic potential markers AA_1, which enable half-wave potentials accurately to be established. Permanently recorded on a 10" wide chart.

**This was an actual problem presented to Mervyn Instruments by a leading chemical manufacturing organisation.*

Speediest, most Accurate, the Fundamental Development in Analysis—and therefore the most Economic. Convenient in Design, Sensitive in Application.

Send for our full technical leaflets, quoting "Nature" to

MERVYN INSTRUMENTS

COPSE ROAD, ST. JOHN'S, WOKING, SURREY.
Telephone: Woking 5200.

LATEST RADIATION MONITOR BY PHILIPS HAS TRANSISTORS & PRINTED WIRING

MEASURES GAMMA RADIATION LEVELS—BETAS TOO . . .

This new Philips Transistorized Pocket Radiation Monitor — the PW 4014 — does duty in the field as well as the laboratory. It can be used as an instrument for ground prospecting in geological survey, as a dose-rate meter by laboratory staffs for determining *tolerance levels*, and as a contamination meter for checking benches and utensils employed in isotope work. It also serves as a monitoring instrument in certain types of tracer studies.

Write now for fully descriptive literature.

Product of N. V. Philips Eindhoven, Holland

SPECIFICATION

Measuring Ranges. *0-3 mr/hr and 0-30 mr/hr. Optional plug-in probe multiplies ranges by 20. (Calibrated against Radium γ Standard.)*

Selector Switch *for operating built-in G.M. tube, x 20 gamma probe, or cable-connected β probe.*

Built-in Check for Battery Volts. *Lowest admissible value indicated on meter.*

Low Current Drain *(only 12 mA). Battery life at least 100 operating hours.*

Light Weight. *Complete with 3-volt battery less than 1½ lbs. Ruggedly constructed.*

Waterproof and Tropic Proof. *If need be, instrument can be de-contaminated by washing.*

Provision for Light Weight Earphone *(hearing-aid type). Permits low intensity radiation to be detected audibly. (An optional feature.)*

Sole distributors in the U.K.

RESEARCH & CONTROL INSTRUMENTS LTD.
Instrument House · 207 King's Cross Rd., London, W.C.1

(RCL0397A)

Rare Earths of highest purity

yttrium lanthanum cerium
praseodymium neodymium
samarium europium gadolinium
terbium dysprosium holmium erbium
thulium ytterbium lutetium

Salts of any of the elements can be prepared to meet individual demands, and most of the rare earth metals can now be produced.

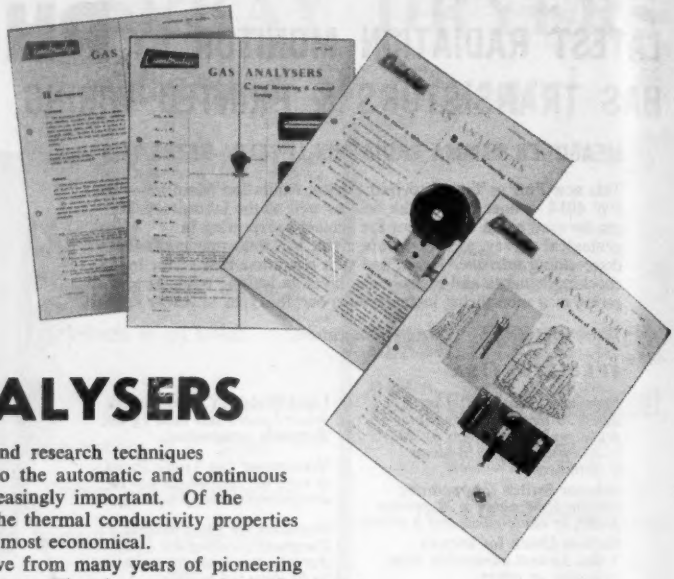
The chemistry of the rare earths has for some years been one of the research projects in the Johnson Matthey laboratories. Methods for the extraction and separation of the rare earths have been steadily developed, and today all fifteen are available in a state of high purity. Details of purity and availability of the rare earths will be forwarded on request.

Johnson Matthey

JOHNSON, MATTHEY & CO., LIMITED
73-83 HATTON GARDEN, LONDON, E.C.1. Telephone: Holborn 6989
Vittoria St., Birmingham, 1. Tel: Central 8004 75-79 Eyre St., Sheffield, 1. Tel: 29212

A complex problem simplified by

Cambridge



GAS ANALYSERS

As new production methods and research techniques are introduced into industry, so the automatic and continuous analysis of gases becomes increasingly important. Of the methods available, that using the thermal conductivity properties of gases is the simplest and the most economical.
Cambridge Gas Analysers derive from many years of pioneering in both research and development. They incorporate the katharometer as their primary measuring element, and this device has been developed to the stage at which the Company can offer a wider range of thermal conductivity gas analysers than any other manufacturer in the world.

Send for List 144N. For future publications, write for Mailing Form N/2/59.

CAMBRIDGE INSTRUMENT COMPANY LTD., 13 GROSVENOR PLACE, LONDON, S.W.1

NO BETTER ANALYTICAL WEIGHT VALUE IS OBTAINABLE

GRIFFIN STAINLESS STEEL

Analytical Weights

Griffin Stainless Steel Analytical Weights are manufactured of 25/20 Cr-Ni and are of one-piece construction with integral knob. This avoids the internal cavities frequently a cause of instability in mass.

All weights are carefully adjusted to the standards specified by the N.P.L. for Class A.

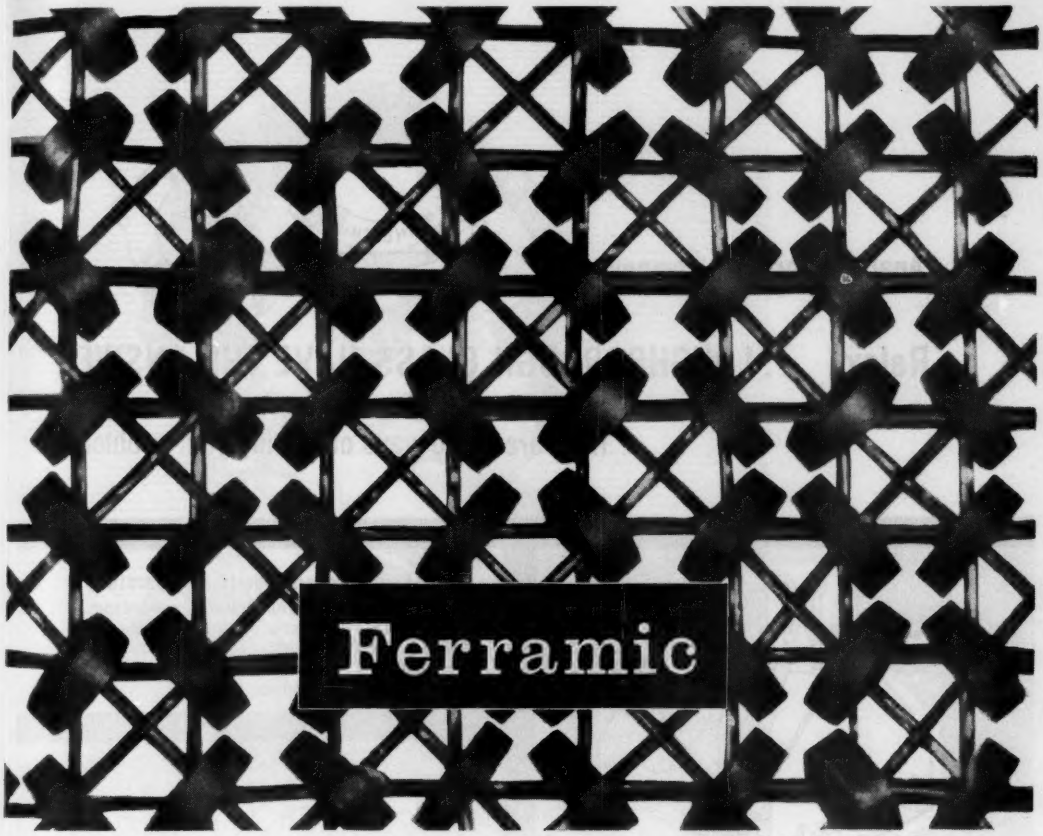
Modern and simplified manufacturing methods enable these weights to be offered at a most economical price.

Supplied in sets of 100 g or 50 g to 10 mg; all of stainless steel in plastics case, with riders 5 mg and 10 mg, tipped forceps and Works' Certificate.

S14-150	10 mg to 50 g...	...	£12 5s. 0d.
	10 mg to 100 g	...	£13 15s. 0d.

GRIFFIN & GEORGE (SALES) LIMITED
Head Office: Ealing Road, Alperton, Wembley, Middlesex
Phone: PERivale 3344

BIRMINGHAM	Frederick Street, 1	Central 2552
MANCHESTER	Cheetham Hill Road, 4	Blackfriars 6041
GLASGOW	Renfrew Street, C2	Douglas 0747
EDINBURGH	Johnston Terrace, 1	Caledonian 4868



FERRAMIC is a registered trade mark

A ferrite to remember

Cores made of Plessey 'Ferramic' material, only ·050" in diameter, make possible the intricate memory planes used in modern computer design. The electrical properties of these microscopic cores have to be critically accurate and 'Ferramic' readily meets the demands.

Other grades of 'Ferramic' are also being made in large quantities for many components requiring a core material of the highest efficiency —television transformers, scanning coils and aerial rods among them. Designers still seeking a core material which will realise the performance they want, at an economical price, are invited to write for data sheets on available grades of 'Ferramic'.

Shown is an enlarged section of a typical Plessey memory plane. Each core is only ·050" in diameter.

Plessey

CHEMICAL AND METALLURGICAL DIVISION · COMPONENTS GROUP
THE PLESSEY COMPANY LIMITED · WOOD BURCOTE WAY · TOWCESTER
NORTHANTS · TELEPHONE: TOWCESTER 312

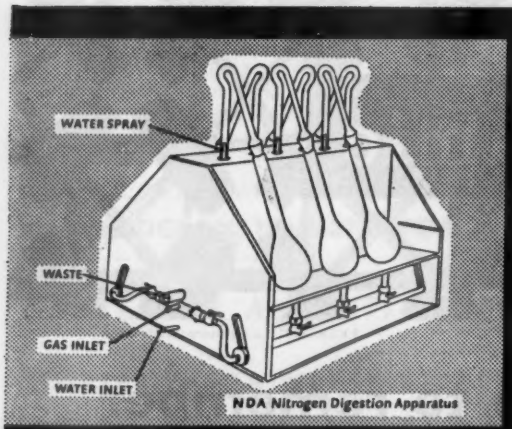
Overseas Sales Organisation:
PLESSEY INTERNATIONAL LIMITED · ILFORD · ESSEX · TELEPHONE: ILFORD 3040

TC96

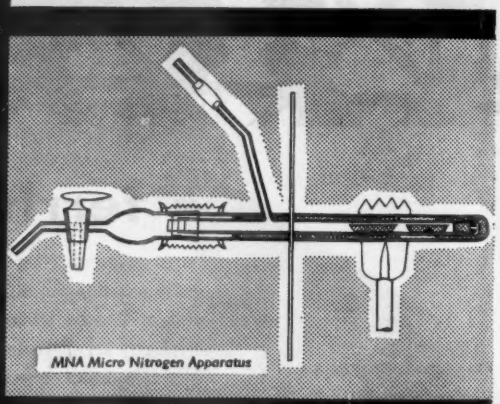
Analysing organic compounds?

Relax! . . . LOUGHBOROUGH GLASS HAVE THE ANSWER

Here are three ways of solving your problems



◀ NDA— Nitrogen Digestion Apparatus
This is for nitrogen estimation according to Kjeldahl. Compact, portable, needs no fume cupboard and will carry out multiple digestions wherever there are gas, water and waste connections.



MNA— Micro Nitrogen Apparatus ▶
A novel assembly—also for determining nitrogen content, but this time by the Dumas and Pregl method. Small quantities—quick answers.

MCA— Micro Combustion Apparatus
A first cousin to MNA, but more general in purpose. A new design for the rapid combustion of organic compounds, including volatile ones.

FULLER INFORMATION FROM:

L G C

LOUGHBOROUGH GLASS COMPANY LTD. LOUGHBOROUGH, LEICS

Telephone: Loughborough 4881 Telegrams: Glass-Telex-Loughborough Telex: 34/629

(R1)

Young and undulations

'A luminous Ether pervades the Universe, rare and elastic in a high degree . . . Undulations are excited in this Ether whenever a Body becomes luminous . . . The Sensation of different Colours depends on the different frequency of Vibrations, excited by Light in the Retina'. And having made clear his firm adherence to the wave theory, Thomas Young proceeds to the world's first measurements of wavelengths. Thus, the *Philosophical Transactions* of 1802 saw a versatile genius stride along the road that has led to Hilger automatic spectrochemical analysis—the quickest, surest, most comprehensive, and most economical method of analysis in research and industry.

HILGER & WATTS

HILGER & WATTS LTD · 98 ST PANCRAS WAY · LONDON · NW1 · *GULliver 5636*

HILGER & WATTS LTD, WITTEN, GERMANY. HILGER & WATTS INC., CHICAGO 5.

LECTURES AND COURSES

UNIVERSITY OF BIRMINGHAM
DEPARTMENT OF CHEMICAL ENGINEERING
COURSE FOR M.SC. (CHEM. ENG.) IN BIOLOGICAL ENGINEERING

A postgraduate course leading to the degree of M.Sc. (Chem. Eng.) in Biological Engineering will commence in October, 1959. The course will extend over one year for students holding a good honours degree or postgraduate diploma in chemical engineering. Honours graduates in physics, biology and biochemistry will be considered for admission to a two-year course, the first year being devoted to general study of the principles of chemical engineering. The M.Sc. course will include the study of microbiology and biochemistry, the design and operation of fermentation equipment, and chemical engineering problems in the food industries and in the biological disposal of effluents. The practical work, including operation of pilot-plant equipment, will be arranged to provide training in research methods. Facilities for research leading to the degrees of M.Sc. or Ph.D. are available.

Further information and forms of application may be obtained by writing to Professor F. H. Garner, the University, Edgbaston, Birmingham, 15.

COLLEGE OF AERONAUTICS
ONE YEAR POSTGRADUATE COURSE IN THE PHYSICS AND MECHANICS OF STRUCTURAL MATERIALS, 1959-1960

Applications are invited for the one year course which begins on October 5, 1959. Prospective students must be of graduate status in an appropriate branch of science or engineering and must have practical experience in one of the fields covered by the course. The purpose of the course is to give instruction in the analytical methods of the theories of elasticity and plasticity and in the basic theories of the nature of materials derived from the sciences of physics, chemistry, and metallurgy.

Further information and forms of application may be obtained from the Warden, The College of Aeronautics, Cranfield, Bletchley, Bucks.

COLLEGE OF AERONAUTICS
A Course of Lectures on
PROBLEMS IN HYPERSONIC AERODYNAMICS
will be given at the College from
Monday, May 11 to Friday, May 22, 1959

The course is intended for aerodynamicists, physicists and research workers who require a working knowledge of hypersonic aerodynamics. A knowledge of subsonic and supersonic aerodynamics and of mathematics up to degree level is desirable. Fees for the course are: Tuition fee, 30 guineas. Residence charge, 10 guineas (including full board).

Forms of enrolment and copies of the syllabus may be obtained from the Warden, the College of Aeronautics, Cranfield, Bletchley, Bucks.

CHELSEA COLLEGE OF SCIENCE AND TECHNOLOGY
MANRESA ROAD, S.W.3
DEPARTMENT OF CHEMISTRY
COLLEGE DIPLOMA IN BIOCHEMISTRY

A three year part-time course (one afternoon and evening per week) comprising lectures and laboratory work, and leading to the above Diploma, will commence in October, 1959. *Graduates in chemistry and other graduates who* have attained an approved standard in chemistry are eligible for admission. In suitable circumstances candidates may be remitted up to one year of the course.

Further details, including application forms and regulations governing the award of the Diploma, may be obtained from the Department. (Fee £3 7s. 6d. per year.) Closing date for application, June 30, 1959.

COLLEGE OF AERONAUTICS
A Course of Lectures on
AERODYNAMIC PRINCIPLES OF THE HELICOPTER
will be given at the College from
Monday, May 4 to Friday, May 8, 1959

The course will deal with the basic aerodynamics and performance of rotating wing aircraft, including discussions on problems of stability and control. Fees for the course are: Tuition fee, £15 15s. Residence charge (including full board), £6 10s.

A copy of the syllabus and forms of enrolment may be obtained from the Warden, the College of Aeronautics, Cranfield, Bletchley, Bucks.

UNIVERSITY OF BIRMINGHAM
DEPARTMENT OF CHEMICAL ENGINEERING
POSTGRADUATE COURSE IN CHEMICAL ENGINEERING

A Course exists in the department leading to the degree of M.Sc. (Chem. Eng.) by examination and is open to graduates in chemical engineering who hold a good honours degree in the subject. Some industrial experience is preferable although not essential, and the course extends over one year—from October 1 until September 30. The Course includes the study of fluid flow, heat transfer, mass transfer, reaction kinetics and reactor design, together with applications of higher mathematics in chemical engineering. A practical chemical engineering investigation is also required of the student. The Course is approved by D.S.I.R. for the award of Advanced Course Studentships. Alternatively, certain University Maintenance Awards may be made available to suitable applicants. The Course fee is £81.

Further information and forms of application for admission may be obtained from Professor F. H. Garner, the University, Edgbaston, Birmingham, 15.

NORTHAMPTON COLLEGE OF ADVANCED TECHNOLOGY
LONDON
ST. JOHN STREET, E.C.1
DEPARTMENT OF APPLIED CHEMISTRY

Head of Department: J. Leicester, M.Sc., M.Sc.Tech., Ph.D., F.R.I.C.

PHOTOGRAPHIC CHEMISTRY
WITH SPECIAL REFERENCE TO
COLOUR PHOTOGRAPHY

A course of eight lectures and practical work will be held on Thursday afternoons at 2 p.m., commencing on April 9, 1959.

The course is suitable for graduates or holders of H.N.C. in chemistry.

FEE FOR THE COURSE £2 2s.

Enrolment can be effected by personal attendance at the College or by application for an enrolment card.

IMPERIAL COLLEGE OF SCIENCE AND TECHNOLOGY
LONDON, S.W.7

A course of six lectures on "Modern Methods of Gas Analysis" will be given by Dr. G. J. Minkoff, in the Chemical Engineering Department, on Mondays at 2.30 p.m., commencing April 27, 1959.

Further particulars from the Registrar, Imperial College, London, S.W.7.

CHELSEA COLLEGE OF SCIENCE *AND TECHNOLOGY*
MANRESA ROAD, S.W.3
DEPARTMENT OF CHEMISTRY
FULL-TIME COURSES LEADING TO GRADUATE MEMBERSHIP OF ROYAL INSTITUTE OF CHEMISTRY, COMMENCING SEPTEMBER, 1959

Applications are invited for a one year's course in preparation for Part II of the Graduateship examination. Candidates should have already passed or gained exemption from (i) Part I of the examination, and (ii) all ancillary subjects.

Apply to Head of Department.

IMPERIAL COLLEGE OF SCIENCE AND TECHNOLOGY
TECHNICAL OPTICS SECTION
A combined Lecture and Practical Course on
COLORIMETRY AND SPECTROPHOTOMETRY
with special reference to Colour Reproduction
will be given by Professor W. D. Wright on
Fridays, May 1, 8, 15, 22, 29 and June 5, 1959.

Two lectures will be given on each Friday, together with experimental work and discussion. *The fee for the Course is £4 4s.*

Application for admission should be addressed to the Registrar of the Imperial College, Prince Consort Road, London, S.W.7.

OFFICIAL APPOINTMENTS

UNIVERSITY COLLEGE OF NORTH WALES
BANGOR

Applications are invited for a Research Fellowship at the Marine Biology Station. The Fellowship is made available by the Red Hand Compositions Company for research into mechanisms of toxicity. The value of the Fellowship will be not more than £750 per annum with increments of £50 per annum and participation in F.S.S.U.; it will be tenable in the first instance for a period of three years. Applicants should have Ph.D. or equivalent experience in an appropriate subject, such as Biochemistry, Animal or Plant Physiology.

Applications, together with the names of three referees, should be sent before April 18, 1959, to the Registrar, University College of North Wales, Bangor, from whom further particulars may be obtained.

UNIVERSITY COLLEGE OF SWANSEA

Applications are invited for the appointment of Superintendent of Laboratories in the Department of Chemistry. This is a newly established post of Assistant Lecturer or Lecturer Status. The appointment is suitable for a chemistry graduate who couples an interest in experimental techniques with one in the development of a good administrative pattern in a new laboratory. The commencing salary will be on the scale £700 by £50 to £850 or £900 to £1,650, according to age, qualifications and experience. There is provision for membership of F.S.S.U. and for children's allowances.

Further particulars can be obtained from the Registrar, University College, Singleton Park, Swansea, by whom applications (six copies) must be received by April 20, 1959.

UNITED CAMBRIDGE HOSPITALS
ADDENBROOKE'S HOSPITAL

Applications are invited for an appointment as Assistant Physicist in the Radiotherapeutic Centre at the above Hospital. Duties will be concerned with a wide variety of applications of physics to clinical radiotherapy and other branches of medicine. Candidates should possess an honours degree in physics. Some previous experience of hospital physics would be an advantage, but is not essential. Salary according to Whitley Council scales for the Basic Grade, £625 to £1,000 per annum.

Applications, together with the names of two referees, should be sent to the Secretary, Addenbrooke's Hospital, Cambridge, within fourteen days of the appearance of this advertisement. Further particulars of the post may be obtained on application to the Principal Physicist.

ROYAL NAVAL SCIENTIFIC SERVICE *requires SENIOR SCIENTIFIC OFFICERS* and SCIENTIFIC OFFICERS for Establishments in London area, Baldock, Portsmouth, Portland, Poole, and Rosyth. Main requirements are for PHYSICISTS, MECHANICAL ENGINEERS, ELECTRONIC ENGINEERS and MATHEMATICIANS in areas specified. The following particular vacancies also exist: Mathematician: for applied research of basic nature on stability of underwater vehicles; knowledge of theoretical hydrodynamics and theory of control systems an advantage: *London area. Mechanical Engineer:* with sound knowledge of basic principles of thermo- and fluid-dynamics to carry out research programme in a particular field of applied hydrodynamics. Experience in modern methods of design and research on axial flow compressors, turbines or pumps an advantage: London area. Mechanical Engineers: for design and development of underwater devices: Portland area. Physical Chemist: with specialized knowledge of rubber technology: Poole area. Chemists: Physical and Inorganic: Poole, Baldock and London areas. Candidates must normally be natural born British subjects of natural born British parents, with first- or second-class honours degrees. *Senior Scientific Officers must have had three* years' postgraduate experience and be not less than 26 years of age. Salaries (men): Senior Scientific Officer, £1,233 to £1,460; Scientific Officer, £655 to £1,150 (London)—somewhat lower in provinces. Appointments are unestablished (with F.S.S.U. benefits) but opportunities may occur for those between ages 21 and 32 to compete for established posts.—Forms from Ministry of Labour and National Service, Technical and Scientific Register (K), 26 King Street, London, *S.W.1 (quote A.500/8A).*

CHELSEA COLLEGE OF SCIENCE AND TECHNOLOGY

MANRESA ROAD, LONDON, S.W.3

DEPARTMENT OF PHYSICS

Applications are invited from honours graduates for the following posts: (a) Senior Lecturers. (b) Lecturers. (c) Assistant Lecturers. Preference will be given to graduates with research experience, and opportunities for continuing research will be provided. Applicants for the senior posts will be expected to have appropriate teaching experience. The salary scales attached to these grades are as follows: (a) Senior Lecturer, men £1,417 10s. by £52 10s. to £1,627 10s. ; women, £1,336 9s. to £1,627 10s. ; (b) Lecturer, men, £1,260 by £31 10s. to £1,417 10s. ; women, £1,188 to £1,417 10s. ; (c) Assistant (Grade B), men, £682 10s. by £26 5s. to £1,076 5s. ; women, £661 10s. to £1,076 5s., plus additions for training and graduate status. There is, in addition, a London allowance of £37 16s. or £50 8s. according to age. Successful applicants will be placed on these scales in accordance with previous experience in a similar capacity and/or industrial experience.

Particulars and forms of application from the Clerk to the Governors, to whom applications should be submitted by April 18, 1959.

CHELSEA COLLEGE OF SCIENCE AND TECHNOLOGY

MANRESA ROAD, LONDON, S.W.3

DEPARTMENT OF PHYSIOLOGY AND PHARMACOLOGY

The Governing Body invite applications for three posts, Senior Lecturer, Lecturer, and Assistant (Grade B) in Physiology or in Pharmacology. Honours degree essential. Duties include teaching and research. The salary scales attached to these grades are as follows: (a) Senior Lecturer, men, £1,417 10s. by £52 10s. to £1,627 10s. ; women, £1,336 9s. to £1,627 10s. ; (b) Lecturer, men, £1,260 by £31 10s. to £1,417 10s. ; women, £1,188 to £1,417 10s. ; (c) Assistant (Grade B), men, £682 10s. by £26 5s. to £1,076 5s. ; women, £661 10s. to £1,076 5s., plus additions for training and graduate status. There is, in addition, a London allowance of £37 16s. or £50 8s. according to age. Successful applicants will be placed on these scales in accordance with previous experience in a similar capacity and/or industrial experience.

Particulars and form of application from the Clerk to the Governors. Applications to be submitted by May 1, 1959.

UNIVERSITY OF LEEDS

DEPARTMENT OF ELECTRICAL *ENGINEERING*

Applications are invited for appointment as Lecturer in the Department of Electrical Engineering. Candidates should have good academic qualifications and experience in one of the following fields: Electrical power engineering, electrical engineering materials, or electrical engineering physics. Salary on the scale of £900 by £50 to £1,350 (efficiency bar) by £75 to £1,650 according to age, qualifications and experience.

Applications (three copies), stating date of birth, qualifications and experience, together with the names of three referees, should reach the Registrar, the University, Leeds, 2 (from whom further particulars may be obtained) not later than May 2, 1959.

UNIVERSITY OF EDINBURGH

DEPARTMENT OF GEOLOGY

Applications are invited for the post of Lecturer in Geology. Salary scale £900 by £50 to £1,350 by £75 to £1,650 per annum, with placement according to qualifications and experience, and with superannuation benefit and family allowance where applicable. Candidates should have a special interest in Stratigraphy. The successful applicant will be expected to take up duty on October 1, 1959.

Further particulars may be obtained from the undersigned, with whom applications, giving the names of two referees, should be lodged not later than April 11, 1959.

CHARLES H. STEWART,
Secretary to the University.

UNIVERSITY OF CAMBRIDGE

*Applications are invited for a University Lec*turership in History of Science tenable from October 1, 1959. Stipend on scale £1,100 to £1,800, with F.S.S.U. arrangements and family allowances. *Further particulars may be obtained from Mr.* R. F. Holmes, The Old Schools, Cambridge, to whom applications should be sent by April 30, 1959.

R.A.E. RESEARCH FELLOWSHIPS

Ministry of Supply invites applications for a limited number of Senior and Junior Research Fellowships tenable for two or three years at the Royal Aircraft Establishment, Farnborough, Hants, commencing Autumn, 1959. Fellows will be required to carry out Fundamental Research in connection with advanced rocket and aircraft projects. The scientific fields covered include aerodynamics, thermodynamics, aircraft and missile structures, guidance and control techniques, etc. Subjects will be selected according to the training and experience of the Fellows and the interests of the Establishment. Candidates must be British with normally a first- or second-class honours degree in the natural sciences, mathematics or engineering, with evidence of a very high standard of ability in research. Exceptionally a candidate without the academic requirements, but who can produce evidence of outstanding ability in research, may be admitted. At least two years' postgraduate research experience required for Junior Research Fellowships (age preferably 23-26) and three years for Senior Research Fellowships (age preferably 26 to 30). Remuneration according to individual merit on ranges £1,100 to £1,350 (Senior Research Fellowships), £750 to £1,000 (Junior Research Fellowships) a year. Superannuation under F.S.S.U. At the expiry of Fellowship the holder, if of suitable age, can be considered for an established post at the Establishment.

Application forms from the Director, R.A.E. Farnborough, to whom completed forms, together with suitable testimonials regarding research ability and where possible, copies of candidates' published papers, must be returned by April 17, 1959. Overseas candidates should submit written applications, stating age, nationality and place of birth of self and parents, academic qualifications, appointments held and research experience.

UNIVERSITY OF GLASGOW

LECTURESHIP IN PHYSIOLOGY

Applications are invited for a Lectureship in Physiology. Preference will be given to candidates with an interest in histology and histochemistry. Salary scale: £900 to £1,650 per annum for Lecturer without medical qualification ; £900 to £1,700 per annum for Lecturer with a medical qualification. Initial salary according to experience and qualifications. F.S.S.U. and family allowance benefits.

Applications (eight copies) should be lodged, not later than May 16, 1959, with the undersigned, from whom further particulars may be obtained.

ROBT. T. HUTCHESON,
Secretary of University Court.

UNIVERSITY OF GLASGOW

LECTURESHIPS IN MATHEMATICS

Applications are invited for two Lectureships in Mathematics from persons qualified in either Pure or Applied Mathematics. Salary scale: £900 to £1,650. Initial salary according to experience and qualifications. F.S.S.U. and family allowance benefits.

Applications (eight copies) should be lodged, not later than April 18, 1959, with the undersigned from whom further particulars may be obtained.

ROBT. T. HUTCHESON,
Secretary of University Court.

ROTHAMSTED EXPERIMENTAL STATION

HARPENDEN, HERTS

Scientific Officer for Plant Pathology Department to work on virus diseases of field crops. Good honours degree, preferably with postgraduate experience. Starting salary between £615 and £1,090 according to experience. F.S.S.U.

Applications, naming two referees, to the Secretary, by April 30.

D.S.I.R. REQUIRES SCIENTIFIC OFFICER, Mathematician at Building Research Station, Garston, near Watford, Herts, to study thermal effects in engineering structures, and initially to study stresses developed in concrete nuclear shields under operating conditions. Work requires combined knowledge of classical elasticity theory and modern theory of solids. Qualifications: first- or second-class honours degree or equivalent. Salary *£615 to £1,090, postgraduate experience taken* into account in assessing salary. Prospects of promotion to Senior Scientific Officer (£1,166 to £1,380) and Principal Scientific Officer (£1,420 to *£2,020).*—Forms from *Ministry of Labour* and National Service, Technical and Scientific Register (K), 26 King Street, London, S.W.1, quoting A.131/9A. Closing date, April 17, 1959.

FELLOWSHIP IN PROTEIN CHEMISTRY

DIVISION OF PROTEIN CHEMISTRY
COMMONWEALTH SCIENTIFIC AND INDUSTRIAL RESEARCH ORGANIZATION, AUSTRALIA

Applications are invited for a Fellowship in Protein Chemistry at the Organization's Division of Protein Chemistry, Parkville (near University of Melbourne) from Honours graduates in some branch of chemistry, with some postgraduate research experience. Appointee required to apply ultra-violet and visible spectrophotometry in studies of the chemistry of extracted wool proteins and related model compounds and to relate the findings to similar measurements on the intact fibre. Salary—dependent on qualifications and experience with minimum of £A.1,400 and approximate maximum of £A.2,500 per annum. Further details and information on conditions, fares etc., obtainable from:

Mr. E. J. Drake,
Chief Scientific Liaison Officer,
Australian Scientific Liaison Office,
Africa House,
Kingsway, W.C.2,

to whom applications, referring to Appointment No. 462/116, should be addressed by April 25, 1959.

UNIVERSITY OF GLASGOW

UNIVERSITY STUDENTSHIPS AND FELLOWSHIPS

Applications are invited for University Studentships and Fellowships for experimental or theoretical research in Nuclear and Elementary Particle Physics. Salary scale: Studentships, £350 to £600 per annum, according to qualifications, with a tenure of three years. Fellowships, £700 to £900 per annum, according to qualifications. Tenure three years on appointment, with possible renewal for further period of two years. These Fellowships will be superannuated under the F.S.S.U.

Applications, stating age, academic qualifications, research experience and names of two referees, should be sent to the Professor of Natural Philosophy, the University, Glasgow, W.2, before May 9, 1959.

COMMONWEALTH BUREAU OF HELMINTHOLOGY

THE WHITE HOUSE, 103 ST. PETER'S STREET, ST. ALBANS, HERTS

Scientific Assistant required for taxonomic work in connection with identification of helminths of economic importance in agriculture, veterinary science and medicine. Candidates should have an honours degree in zoology and be interested in taxonomic work on helminths. Experience in this field an advantage. Knowledge of Latin and modern languages, though not essential, an additional recommendation. Salary scale £595 to £970 (bar) to £1,330 (bar) to £1,460. Age, qualifications and experience considered when fixing starting salary. Up to two increments for compulsory National Service and two extra increments on completing two years' satisfactory service if ages 32 or under. Superannuation according to F.S.S.U.

Applications, stating age, qualifications and experience, together with the names of three referees, should be sent before June 30, to the Director, from whom further particulars are obtainable.

UNIVERSITY OF ABERDEEN

Applications are invited for the post of Lecturer in Physical Chemistry. An interest in molecular weight measurements or nuclear magnetic resonance would be advantageous. Salary scale £900 to £1,650, with appropriate placing. F.S.S.U. and child allowance.

Particulars from the Secretary, the University, Aberdeen, with whom applications (eight copies) should be lodged by April 15, 1959. Applicants outside the British Isles may submit one copy of application.

GLASSHOUSE CROPS RESEARCH INSTI-

tute require Mycologist for bio-assay work on fungicides in Crop Protection Department. Appointment in Assistant Experimental Officer grade, £492 (age 21) to £855 maximum ; superannuation. Qualifications: G.C.E. (Advanced) in two mathematical or scientific subjects and (Ordinary) in three other subjects including English ; but over 22 pass degree or equivalent preferred. Good grounding in mycological technique an advantage. —Applications, with fullest particulars and names of two referees, to Secretary to the Institute, Worthing Road, Rustington, Littlehampton, Sussex, before April 20, 1959.

CENTRAL ELECTRICITY GENERATING BOARD

PHYSICIST or ENGINEER

required in the Operations Branch, of the Research and Development Department at Headquarters, London.

The successful candidate will be concerned with electrical problems associated with generating and transmission equipment. He will be expected to contribute to the formulation of programmes of research work to be carried out at the Board's Laboratories. This will involve visits to power stations and other sites as well as maintaining contact with relevant research within and outside the industry. A University degree or equivalent or membership of The Institute of Physics is required, whilst research and/or operational experience would be an advantage.

***Salary on a scale within the range £610 to £1,350* per annum, according to duties and responsibilities.**

Application forms obtainable from the

Personnel Officer, 24-30 Holborn, London, E.C.1, should be completed and returned by April 14. Please mark envelopes "Confidential Ref. N/100."

COVENTRY TECHNICAL COLLEGE

(Principal: A. J. Richmond, B.Sc.(Eng.)(Lond.), Ph.D., M.I.Mech.E.)

Applications invited for following full-time posts, duties to commence as soon as possible: *(1) Lecturer in Mechanical Engineering* with special knowledge of strength of materials, or theory of machines, or applied thermodynamics. *(2) Lecturer in Aeronautical Engineering* with special knowledge of applied aerodynamics and/or aircraft performance. Applicants should be university graduates and have had industrial experience. At least graduate membership of appropriate professional body is required. Previous teaching experience is not essential. Burnham *Technical Scale Salary (men): £1,260* to £1,417 10s. per annum. Women receive slightly less at present but equal pay will apply by 1961.

Further particulars and application forms from the Principal, Butts, Coventry, to whom applications should be submitted by April 16, 1959.

W. L. CHINN,
Director of Education.

RESEARCH CHEMIST

MINERALS UTILIZATION SECTION—CHEMICAL RESEARCH LABORATORIES
COMMONWEALTH SCIENTIFIC AND INDUSTRIAL RESEARCH ORGANIZATION, AUSTRALIA

Applications are invited for appointment as Research Chemist at the Organization's Chemical Research Laboratories from honours graduates in science, specializing in physical or inorganic chemistry with several years' postgraduate research experience in minerals utilization especially on the hydrometallurgical treatment of a variety of ores an advantage but not essential. Considerable freedom given in developing individual approach to investigations.

Salary—depending on qualifications and experience in the ranges: £A.1,326 to £A.1,951 per annum or £A.2,061 to £A.2,336 per annum. Further details and information on conditions, fares, etc., obtainable from:

Mr. E. J. Drake,
Chief Scientific Liaison Officer,
Australian Scientific Liaison Office,
Africa House,
Kingsway, W.C.2,

to whom applications, referring to Appointment No.: 601/2, should be addressed by April 25, 1959.

AGRICULTURAL TRAINEE. COLONIAL Development Corporation requires graduate with agricultural degree. Single man with one year's postgraduate training preferred. The successful candidate will be required to start work in London in August and to attend D.T.A. course at I.C.T.A. Trinidad, from October, 1959 to June, 1960. This will be followed by overseas posting at pensionable salary of about £700 per annum plus overseas allowances.—Apply, giving full particulars, to Personnel Officer, 33 Hill Street, London, W.1, quoting serial 359.

ESSEX INSTITUTE OF AGRICULTURE

WRITTLE, NR. CHELMSFORD

Applications are invited for the post of Senior Assistant in Agricultural Chemistry. Salary *£1,050 by £30 to £1,200.* Alternatively, applications are invited from more junior men for appointment as Lecturer (Assistant, Grade II) in Agricultural Chemistry at a salary of £550 by £25 to £975. Additions to both scales are payable for approved qualifications and training and the 5 per cent special increases. The starting point for *either salary can be influenced by recognized* previous service.

Details and forms (S.A.F.E.) from the Clerk to the Governors, at the Institute.

UNITED NATIONS TECHNICAL ASSISTANCE PROGRAMME

The International Atomic Energy Agency invites applications for the appointment of an Expert in Gamma-irradiation and Radioisotope problems to assist Pakistan Atomic Energy Commission in connection with Government Institute of Nuclear Research and Reactor Technology in Pakistan. Must have considerable research experience in gamma-irradiation problems and radioisotope techniques. Duration one year. Salary AQE, but total remuneration, including allowances, expected to be of the order of $13,500 for married men with two children.

For further information and application forms, write to Ministry of Labour and National Service, 26/28 King Street, London, S.W.1, quoting E9/39/IAEA/PAK.

BRITISH GUIANA SOIL SURVEYOR

For soil surveys on the coastlands and the undeveloped interior. Candidates must have a university degree, preferably with honours, in agricultural chemistry or pure chemistry; or alternatively a degree in geology or geography and a good knowledge of chemistry. Appointment on contract/gratuity terms with salary in scale £890 to £1,400 per annum. Gratuity 22½ per cent of basic salary. Outfit allowance £60. Free return passages for officer, wife and up to three dependent children under 18 years of age. Furnished quarters, if available, at low rental.

Apply, giving brief particulars, to Director of Recruitment, Colonial Office, London, S.W.1, quoting BCD.63/30/017.

IMPERIAL COLLEGE OF SCIENCE AND TECHNOLOGY

Lecturer in Plant Physiology with research and teaching experience required for October, 1959. Salary in the scale £900 by £50 to £1,350 (bar) by £75 to £1,650 according to age and experience; plus £60 London allowance, F.S.S.U. benefits and family allowances.

Apply to the Professor of Plant Physiology, Imperial College, Prince Consort Road, London, S.W.7.

REACTOR ENGINEERS AND PHYSICISTS

The Nuclear Research Division at Aldermaston is forming a team of Engineers and Physicists for studies on the design, utilization and operation of the "HERALD" light water moderated research reactor, shortly to be commissioned.

To improve its flexibility and performance, *compatible with* safety, the technology of the system requires further study. This involves problems in reactor physics, heat transfer and hydraulics, especially relating to the transient behaviour of the system.

The design of experimental apparatus to be exposed to the core radiation involves problems in radiation induced thermal stress and the handling of large quantities of radioactivity, as well as involving the optimization of the reactor core to meet a variety of experimental requirements.

An I.B.M. 704 computer is available for the solution of major calculations and a zero energy reactor is provided as a permanent instrument for the rapid solution of core problems. The support of large design and development organizations in the Division will be available.

The posts will be graded in the Engineer and Scientific Officer Classes.

For the engineering posts apprenticed engineers with Corporate Membership of a Senior Institution, or equivalent, are required. For these men a training period of shift operation of the reactor may be involved.

For the scientific posts candidates should have an honours degree in physics or a mathematical branch of engineering.

Experience in any of the above mentioned fields will be an advantage but training will be provided for those without experience.

SALARY: ENGINEERS, £845 to £2,155
SCIENTIFIC OFFICER CLASS, £675 to £2,155

Contributory Superannuation Scheme. A house, or alternatively, substantial assistance with house purchase, will become available for married officers living beyond daily travelling distance.

Postcards for application forms to the Senior Recruitment Officer at Atomic Weapons Research Establishment, Aldermaston, Berks. Please quote reference 2204/34.

NATIONAL COLLEGE OF FOOD TECHNOLOGY

Cranwood Street, City Road, London, E.C.1
Principal: J. D. Mounfield, M.Sc.Tech., Ph.D., F.R.I.C.

Applications are invited for the post of Assistant Lecturer in the College from Graduates in Physics or Engineering. Special consideration will be given to applicants with experience in industrial engineering. A new College, now almost completed at Weybridge, Surrey, will come into use in October this year and the candidate appointed will be expected to assist with the development of the Courses there. New laboratories will provide facilities for original work. Salary scale: £813 15s. by £26 5s. to £1,207 10s. The starting salary will be dependent on qualifications and experience.

Application forms (obtainable from the College) should be sent to the Principal as soon as possible.

BATTERSEA COLLEGE OF TECHNOLOGY

LONDON, S.W.11

Applications are invited for the post of Reader in Applied Mathematics. Candidates should possess a good degree of a British university, with research qualifications in some branch of applied mathematics or statistics. Experience of teaching in a university or major technical college is desirable, and some industrial experience will be an advantage. Salary £1,665 by £52 10s. to £1,940 less statutory deductions.

Further particulars may be obtained from the Clerk to the Governing Body, by whom applications should be received as soon as possible.

TEA RESEARCH INSTITUTE OF CEYLON
POST OF CHIEF ADVISORY OFFICER

Applications are invited for the post of Chief Advisory Officer in the Tea Research Institute of Ceylon. *Applicants should possess an honours* degree in agriculture or a postgraduate degree in agricultural science. They should have considerable experience of agricultural extension work and the conduct of field experiments, and some knowledge of agricultural statistics. The selected officer will be expected: (i) To organize and administer the proposed *new Advisory Division of the Tea* Research Institute of Ceylon, (ii) to conduct research on agronomic problems of importance to the tea-growing industry, and (iii) to plan and supervise agronomic experiments. The salary scale attached to the above post is: £2,250 by £50 to £3,000 inclusive of allowances. The selected officer may be placed at any point on the above scale according to his qualifications and experience. He will be required to contribute from 10 to 15 per cent of his basic salary to an approved Provident Fund, *and the Institute will contribute* a further 15 per cent. Certain medical benefits are payable. A free house with basic hard furniture will be provided. Further details will be sent on request.

Applications should give full details of the candidate's qualifications and experience and *should be sent under registered cover to Dr.* F. R. Tubbs, East Malling Research Station, Nr. Maidstone, Kent, England, on or before April 10, 1959.

UNIVERSITY OF BRITISH COLUMBIA

Applications are invited for positions in the Department of Mathematics. Candidates should preferably hold the degree of Ph.D. or equivalent. *Salary ranges:* Instructor, from $5,100 to $6,500; Assistant Professor, from $6,600 to $8,400; Associate Professor, from $8,500 to $11,000; Professor, from $11,200.

Further particulars may be obtained from the Department of Mathematics, University of British Columbia, Vancouver 8, Canada.

MINISTRY OF AGRICULTURE
KENYA
MARKET RESEARCH OFFICER

To study the market in East Africa for a wide range of local agricultural produce and to advise on local market trends and potentialities. Candidates should have an honours degree in agricultural economics, economics or commerce, but those with considerable experience, in a responsible position, of agricultural produce marketing may be considered. Age limit 45 years. Appointment on probation to the permanent establishment with pensionable emoluments in range £939 to £1,863 per annum or on contract/gratuity terms. Free passages on appointment and leave for officer, wife and children up to a maximum cost equivalent to three adult passages in all. Furnished Government quarters, when available, at moderate rental.

Apply, giving brief particulars, to Director of Recruitment, Colonial Office, London, S.W.1, quoting BCD.63/7/038.

BOTANY SCHOOL
OXFORD

Posts of University Demonstrator (£900 to £1,750) and Departmental Demonstrator (£750 to £900) in Biochemistry, Ecology, Physiology and Virology are available in this Department; also Grant-aided Scholarships (£500 to £800) in these subjects and in Genetics and Cytology.

Apply with references before April 20, to the Sherardian Professor of Botany.

MINISTRY OF SUPPLY, ROYAL RADAR Establishment, Malvern, offers first-class opportunities to Scientists in very wide range of research and development work including solid state physics, radio astronomy, advanced computing techniques, electronics and radar. Well equipped laboratories near attractive residential area at foot of Malvern Hills. Official hostel and housing scheme. Five-day week. Appointments in grade (a) Senior Scientific Officer (minimum age 26 and at least three years postgraduate research experience) or (b) Scientific Officer. First- or second-class honours degree or equivalent required for both grades. Salary ranges: (a) £1,166 to £1,380; (b) £615 to £1,090 (male in provinces; rates for women same by 1961). F.S.S.U. superannuation. Opportunities if under 31 to compete for pensionable posts.—Forms and illustrated booklet from Ministry of Labour and National Service, Technical and Scientific Register (K), 26 King Street, London, S.W.1 (quote A 132/9A).

TEA RESEARCH INSTITUTE OF CEYLON
POST OF PLANT BREEDER

Applications are invited for the post of Plant Breeder in the Tea Research Institute of Ceylon. *Applicants should possess an honours degree in* botany and have experience in plant breeding or a postgraduate qualification in genetics or plant breeding. The salary scale attached to the above post is: £2,250 by £50 to £3,000 inclusive of allowances. The selected officer may be placed at any point on the above scale according to his *qualifications and experience.* He will be required to contribute from 10 to 15 per cent of his salary to an approved Provident Fund, and the Institute will contribute a further 15 per cent. *Certain medical benefits* are payable. A free house with basic furniture will be provided. Further details will be sent on request.

Applications, which should give full details of the candidate's qualifications and experience, should be sent under registered cover to reach Dr. F. R. Tubbs, East Malling Research Station, Nr. *Maidstone, Kent, England,* on or *before* April 10, 1959.

UNIVERSITY OF THE WITWATERSRAND
JOHANNESBURG
DEPARTMENT OF SOCIAL ANTHROPOLOGY AND AFRICAN ADMINISTRATION

Applications are invited from persons with qualifications in social anthropology for appointment to a post of Lecturer on the staff of the Department of Social Anthropology and African *Administration. Teaching experience* and knowledge of African administration will be recommendations. Duties are to be assumed as soon as possible. The salary will be according to the scale £1,170 by £60 to £1,650 per annum. A commencing salary above the minimum notch may be paid on the grounds of special qualifications or experience. *Membership of the University* Institutions Provident Fund is compulsory, and membership of the University's Staff Medical Aid Fund is compulsory in the case of an officer who *is found eligible in terms of the rules.*

Intending applicants are advised to obtain a copy of the Information Sheet relating to this *vacancy from the Secretary,* Association of Universities of the British Commonwealth, 36 Gordon Square, London, W.C.1. Applications close, in South Africa and London, on April 21, 1959.

DEPARTMENT OF AGRICULTURE
KENYA
LABORATORY TECHNOLOGIST (PLANT PATHOLOGIST)

To assist with laboratory research and field experiments in problems of coffee pathology and physiology. Candidates must have a university degree with botany as main subject. Appointment on probation to the permanent establishment with pensionable emoluments in scale £813 to £1,341 per annum, or on contract/gratuity terms if preferred. Outfit allowance £40. Free passages on appointment and leave for officer, wife and children up to a maximum equivalent to three adult passages in all. Furnished quarters at moderate rental available.

Apply, giving brief particulars, to Director of Recruitment, Colonial Office, London, S.W.1, quoting BCD.63/7/046.

UNIVERSITY OF HULL

Applications are invited for a Research Fellowship in the Chemistry Department, for an investigation of the mode of action of germicides, to commence on October 1, 1959, or earlier if possible. Salary £750 per annum. A Ph.D. degree or equivalent research experience in Physical-Organic Chemistry or Biochemistry will be required.

Applications (three copies), giving the names of two referees, should reach the Professor of Chemistry, from whom further details may be obtained, by April 30, 1959.

UNIVERSITY OF GLASGOW
LECTURESHIP IN GEOLOGY

Applications are invited for a Lectureship in Geology. Salary scale: £900 to £1,650. Initial salary according to experience and qualifications. F.S.S.U. and family allowance benefits.

Applications (eight copies) should be lodged, not later than April 20, 1959, with the undersigned, from whom further particulars may be obtained.

ROBT. T. HUTCHESON,
Secretary of University Court.

IMPERIAL COLLEGE OF TROPICAL AGRICULTURE
TRINIDAD, WEST INDIES
DEPARTMENT OF SUGAR CHEMISTRY AND TECHNOLOGY
ANALYST AND PHYSICAL CHEMIST

Applications are invited for the post of Analyst and Physical Chemist in the British West Indies Sugar Research Scheme which is attached to the Imperial College of Tropical Agriculture in Trinidad. Candidates should have a good honours degree and suitable research experience preferably industrial but not necessarily in the sugar industry. The appointments will either be in the scale £1,150 to £1,900, or £1,500 to £2,250, entry on either scale according to qualifications and experience, *with children's allowances of £150, £100,* £50 and participation in a scheme similar to the F.S.S.U. scheme.

For further particulars and application forms, which should be returned by May 18, 1959, write to the Secretary, the Imperial College of Tropical Agriculture, 40 Norfolk Street, London, W.C.2.

COUNTY BOROUGH OF STOCKPORT

Applications are invited for the following full-time posts at Stockport College for Further Education: (1) Graduate Assistant Lecturer, Grade "B," in the Science Department to teach Physics and Mathematics to O.N.C. and G.C.E. ("A" level). Start on September 1, 1959. (2) Graduate Assistant Lecturer, Grade "B," in the Department of General Studies to teach Chemistry, Physics, Mathematics to G.C.E. ("O" level). Start on September 1, 1959. Burnham Technical School, N.J.C. Conditions.

Application forms from Principal, Stockport College for Further Education, Wellington Road South, Stockport, to be returned by April 11, 1959.

UNIVERSITY COLLEGE OF NORTH STAFFORDSHIRE

Applications are invited for the post of Assistant Lecturer in Physics. Salary in the scale £700 by £50 to £850 per annum with F.S.S.U. and children's allowances.

Applications should reach the Registrar, the College, Keele, Staffs, from whom further particulars and application forms may be obtained, not later than April 20, 1959.

COMMONWEALTH AGRICULTURAL BUREAUX

The Executive Council invites applications for the post of Assistant Director, Bureau of Horticulture and Plantation Crops, East Malling Research Station, East Malling, Maidstone, Kent, England. Candidates should possess a good degree or equivalent qualification in a biological science and experience of annual and perennial crops. A knowledge of foreign languages and experience in editing scientific publications would be assets. Salary £1,370 to £1,950 with provision for superannuation. Starting point depends on age, qualifications and experience.

Applications should be submitted by June 14, 1959, to: The Secretary, Commonwealth Agricultural Bureaux, Farnham House, Farnham Royal, Bucks, England, from whom further particulars, including passage regulations, can be obtained.

D.S.I.R. REQUIRE SENIOR SCIENTIFIC Officer (Physical Chemist) at Building Research Station, Garston, near Watford, Herts, for work on metallic corrosion and corrosion prevention in building and civil engineering. Previous experience in metallic corrosion work an advantage. Opportunity for varied research involving both the study of corrosion problems and the application of fundamental and practical corrosion knowledge to the prevention of corrosion. Publication of results is encouraged. Qualifications: first- or second-class honours degree, preferably with metallurgical training and/or experience. Salary: £1,166 to £1,380. Prospects of promotion to Principal Scientific Officer (£1,420 to £2,020).—Forms from Ministry of Labour and National Service, Technical and Scientific Register (K), 26 King Street, London, S.W.1, quoting reference F.184/9A. Closing date, April 10, 1959.

ZOOLOGIST (LIMNOLOGY AND Ichthyology) required by an expanding Department with excellent teaching and research opportunities. A Ph.D. with experience preferred for a position up to Associate Professor ($8,400 per annum). Good pension and insurance plans. Appointment begins September 1, 1959.—Apply to Chairman, Department of Zoology, University of Manitoba, Winnipeg 9, Manitoba.

SOUTH WARWICKSHIRE HOSPITAL GROUP

Research Biochemist required to assist in the investigation of Lipid Metabolism in Atherosclerosis. Applicants should have an honours degree in chemistry or biochemistry. Experience an advantage but not essential and graduates will be considered. Appointment is for one year in the first instance. Salary within the scale £645 to £730.

Applications should be made to the Group Pathologist, Group Laboratory, Lakin Road, Warwick, accompanied by the names of two referees.

SELLY OAK HOSPITAL

BIRMINGHAM, 29

Applications are invited for the post of Assistant Biochemist (basic grade) for the Department of Pathology, Selly Oak Hospital. Further particulars of the post from the Biochemist.

Applications, stating age, qualifications and experience, should be submitted to the Administrator, Selly Oak Hospital, Birmingham, 29.

UNIVERSITY OF LONDON

READERSHIP IN GEOGRAPHY AT QUEEN MARY COLLEGE

The Senate invite applications for the Readership in Geography tenable at Queen Mary College (salary scale £1,475 to £1,775 to £2,150 a year plus £80 London allowance).

Applications (ten copies) must be received not later than April 27, 1959, by the Academic Registrar, University of London, Senate House, W.C.1, from whom further particulars may be obtained.

CHELSEA COLLEGE OF SCIENCE AND TECHNOLOGY

MANRESA ROAD, S.W.3

DEPARTMENT OF CHEMISTRY

Applications are invited for the appointment of Lecturer in Organic Chemistry. Salary scale: £1,260 by £31 10s. to £1,417 10s. (men); £1,188 to £1,417 10s. (women), plus London allowance of £37 16s. or £50 8s.

Particulars and forms of application from the Clerk to the Governors to whom applications should be submitted by not later than April 13, 1959.

UNIVERSITY OF LIVERPOOL

DEPARTMENT OF ORGANIC CHEMISTRY

Applications are invited for a Chief Technician. Duties will include supervision of laboratories and technical staff, as well as responsibilities for furnishing and equipping new laboratories planned for completion in 1962. Initial salary in the range £745 to £825 per annum, or, in very special cases, up to £935.

Applications (two copies) in writing, quoting Reference Number 240, to the Registrar, the University, Liverpool, 3.

UNIVERSITY OF BRISTOL

Applications are invited for the post of Assistant Lecturer (Grade III) or Demonstrator in Chemical Physiology. Initial salary £700 to £1,100 per annum according to qualifications and experience, together with superannuation and children's allowances.

Applications, with the names of three referees, should be forwarded so as to reach the undersigned, from whom further particulars may be obtained, not later than April 8, 1959.

H. C. BUTTERFIELD,
Registrar and Secretary.

UNIVERSITY OF CAMBRIDGE

SCHOOL OF VETERINARY MEDICINE

Research Assistant, science graduate, required to carry out experimental work on animal blood-groups. Previous experience in serology and blood-group studies would be an advantage.

For particulars apply to the Administrative Secretary, School of Veterinary Medicine, Madingley Road, Cambridge.

ROYAL VETERINARY COLLEGE (University of London). Applications are invited for appointment as Assistant Lecturer in Chemistry tenable in the Department of Physiology. Salary: £700 by £50 to £850 per annum plus £60 per annum London allowance. Initial salary within the scale according to experience and qualifications. Superannuation benefits and children's allowances.—Application forms, obtainable from the Secretary, Royal Veterinary College, Royal College Street, London, N.W.1, should be returned not later than April 11, 1959.

TOBACCO RESEARCH BOARD OF RHODESIA AND NYASALAND

Applications are invited for the appointment to the Board's staff of a Soil Scientist possessing a Ph.D. degree in soil chemistry and preferably with some experience, to carry out soil fertility investigations, both applied and fundamental in relation to tobacco and supervise routine soil analysis. Salary grade: £1,640 to £1,960 per annum. The commencing salary will be determined by experience. Travelling and reasonable incidental expenses to Salisbury for the successful applicant and, where applicable, his family, will be refunded by the Board. Conditions of service include 30 days annual leave, accumulative to a maximum of four months, plus occasional leave up to 12 days per annum. There is also a Provident Fund and Medical Aid Scheme, membership of which is obligatory.

Applications, accompanied by a photograph and giving full personal details as well as particulars of qualifications and experience and the names of two referees, should be addressed to reach the Director, P.O. Box 1909, Salisbury, Southern Rhodesia, not later than May 31, 1959.

BRADFORD INSTITUTE OF TECHNOLOGY

Principal: E. G. Edwards, Ph.D., B.Sc., F.R.I.C.

Applications are invited for the post of Senior Lecturer in Physics in the Institute. The Senior Lectureship is one of a number of additional posts established as a result of the extension of the work of the Department. Candidates for the post should be well qualified physicists, and some experience of the application of physics in industry would be a recommendation. The capacity to guide research work is a desirable qualification, and suitably qualified candidates will be given the time and facilities to undertake research. The salary scale for men, in accordance with the Burnham Technical Award, is from £1,417 10s. to £1,627 10s. per annum. Previous industrial or research experience at a suitable level may be taken into account in fixing the commencing salary.

Further particulars of the appointment and forms of application may be obtained from the Registrar, Bradford Institute of Technology, Bradford, 7.

W. H. LEATHEM,
Clerk to the Governors.

UNIVERSITY OF HULL

Applications are invited for an Assistant Lectureship in Botany, tenable from October 1, 1959. Salary scale £700 by £50 to £850 per annum, with F.S.S.U. and children's allowances. Applicants should be interested in plant physiology or the genetics of micro-organisms.

Further particulars may be obtained from the undersigned, to whom applications (five copies) should be sent not later than May 1, 1959.

W. D. CRAIG,
Registrar.

UNIVERSITY OF ST. ANDREWS

QUEEN'S COLLEGE, DUNDEE

DEPARTMENT OF PHARMACOLOGY AND THERAPEUTICS

Applications are invited for an Assistantship in Pharmacology in the Department of Pharmacology and Therapeutics, Queen's College, Dundee, in the University of St. Andrews, commencing October 1, 1959. Applicants should have a good honours degree in pharmacology. Salary: £700 by £50 per annum to £850; F.S.S.U.; family allowance. The appointment will be for three years in the first instance may be continued in special circumstances for a fourth and final year.

Applications (six copies), including the names of three referees, to the undernoted, from whom further particulars may be obtained, not later than May 16.

PATRICK CUMMING,
Joint Clerk to the University Court,
Queen's College, Dundee.

UNIVERSITY COLLEGE OF NORTH STAFFORDSHIRE

CHAIR OF PHYSICS

Applications are invited for the Chair of Physics to be rendered vacant from October 1, 1959, by the appointment of Professor F. A. Vick to the Deputy Directorship of the A.E.R.E. at Harwell. Salary £2,300 per annum. F.S.S.U. and children's allowances.

Applications must be received not later than May 9, 1959, by the Registrar, the College, Keele, Staffs, from whom forms and further particulars may be obtained.

NATIONAL INSTITUTE FOR RESEARCH IN DAIRYING

(UNIVERSITY OF READING)

Chemist or Biochemist, preferably with post-graduate experience, required in the Department of Radiobiochemistry for fundamental biochemical research, involving the use of radioactive isotopes, and in particular C^{14} and tritium. The appointment will be in the grade of Senior Scientific Officer (£1,166 to £1,420) or Scientific Officer (£615 to £1,120) according to experience, and qualifications.

Applications, naming two referees, to the Secretary, N.I.R.D., Shinfield, Reading, quote ref. 59/2.

HUDDERSFIELD COLLEGE OF TECHNOLOGY

Principal: Dr. W. E. Scott, M.B.E.

DEPARTMENT OF CHEMISTRY, COLOUR CHEMISTRY AND DYEING

Required September 1, 1959, Assistant, Grade "B," to assist in the teaching of physical and inorganic chemistry. An active interest in research, together with experience in teaching and/or industry is desirable. The salary (Burnham Scale) rises to a maximum of £1,025 per annum plus allowances for graduate status (£75 or £125) and training (£25 to £75). All amounts subject to 5 per cent special addition. The commencing salary will depend upon qualifications and experience and may include up to 12 increments in respect of approved service in industry.

Further particulars and forms of application, which must be returned as soon as possible, obtainable from the Principal.

H. GRAY,
Clerk to the Governors.

UNIVERSITY OF ST. ANDREWS

QUEEN'S COLLEGE, DUNDEE

TWO LECTURESHIPS IN ANATOMY

Applications are invited from medically qualified candidates for the above appointments commencing October 1, 1959. Salaries on the scale £900 by £100 per annum to £1,800 (with an efficiency bar at £1,400) according to qualifications and experience; F.S.S.U., family allowance; expenses of removal grant.

Six copies of application, including the names of three referees, should be submitted not later than May 16, to Patrick Cumming, Joint Clerk to the University Court, Queen's College, Dundee, from whom further particulars may be obtained.

UNIVERSITY OF OXFORD

LECTURESHIP IN MATHEMATICS (FLUID DYNAMICS)

The University proposes to appoint with effect from October 1, 1959, a Lecturer in Mathematics with special qualifications in fluid dynamics. Stipend in the scale £900 to £1,750 per annum, plus F.S.S.U. and children's allowances of £50 per annum for each child.

Six copies of applications, with names of two referees, by April 25, 1959, to Secretary of Faculties, University Registry, Oxford, from whom further particulars may be obtained.

UNIVERSITY OF EXETER

Applications are invited for the post of Assistant Lecturer or Lecturer in Applied Mathematics. Salary scales: Lecturers, £900 to £1,650 (with efficiency bar at £1,300); Assistant Lecturers, £700 to £850.

Further particulars may be obtained from the Secretary of the University. Closing date for applications, April 11, 1959.

GRADUATE CHEMIST AND SENIOR Technician required as assistants in an organic chemical research programme.—Applications to Dr. Sadler, Courtauld Institute of Biochemistry, Middlesex Hospital, W.1.

IMPERIAL COLLEGE: ENGLISH ELECTRIC Studentship for research in Aeronautics, value £750 out of which fees must be paid.—Further particulars from the Registrar, Imperial College, London, S.W.7. Closing date, May 16, 1959.

BOTANIST-BACTERIOLOGIST: AN ASSISTANT Professor is needed for September, 1959. $4,500 minimum per eight-month academic year. Include summary of qualifications in initial reply. —Address to Professor W. B. Stallworthy, Department of Biology, Mount Allison University, Sackville, N.B., Canada.

APPOINTMENTS VACANT

PATENTS INFORMATION

CHEMIST (male or female graduate) for information section of Patents and Trade Marks Department, Bakelite Limited, Birmingham. The work involves abstracting, classifying, searching and analysing patents and would provide a progressive position for the right applicant. Previous experience not essential.

Applications, giving details of qualifications and experience, should be sent to the Patents and Trade Marks Manager, Bakelite Limited, Redfern Road, Tyseley, Birmingham, 11.

THE WATER RESEARCH ASSOCIATION is expanding its activity in the field of research into water purification and distribution. To provide increased facilities it is shortly to move from Redhill, Surrey, to a Thameside site in Buckinghamshire. There are two vacancies for physics graduates under 26 years of age. Previous industrial experience is not an essential requirement and applicants will be considered from those confident of graduating this summer.—Applications, in writing, to the Director, the Water Research Association, 18 Linkfield Lane, Redhill, Surrey.

APPLICATIONS ARE INVITED FOR THE post of Assistant Technical Secretary (male or female) in the Plant Engineering and Energy Division of the British Iron and Steel Research Association, which is engaged on research into the design of plant for the iron and steel industry. Duties include assistance with the technical administration of the Division, the co-ordination of the work of the Research Committees, the editing of reports, the arranging of conferences and liaison with other Divisions of the Association, etc. A graduate with scientific or engineering background and broad outlook preferred, also some experience in administration and/or in the iron and steel industry would be an advantage. The laboratories are situated at 140 Battersea Park Road, London, S.W.11. Salary according to age, qualifications and experience. Post is superannuated under the F.S.S.U.—Written applications only, quoting "A.T.S.6," to Personnel Officer, B.I.S.R.A., 11 Park Lane, W.1.

BRITISH PETROLEUM COMPANY LIMITED has a vacancy for a Physicist with an honours degree for work at its Research Station at Sunbury-on-Thames, Middlesex. Successful applicant will join a group studying the fundamentals and the practical application of filtration and the separation of water from oil fuels. Age, under 35. Salary according to age, qualifications and experience. Non-contributory pension fund. Assisted House Purchase Scheme. Removal expenses and settling-in allowance payable in certain cases. Luncheon club.—Write, giving full particulars, quoting reference H.4454, to Box 6029, c/o 191 Gresham House, E.C.2.

SEMICONDUCTOR SURFACES

A PHYSICAL CHEMIST interested in the investigation of semiconductor surfaces is required to work on this subject in the Research Department of Mullard Southampton Works.

Please apply in writing to the Plant Personnel Officer,

MULLARD SOUTHAMPTON WORKS
Millbrook Industrial Estate,
Southampton.

THE BRITISH SOCIETY FOR RESEARCH in Agricultural Engineering requires a Scientific Officer (Physicist) to carry out original work in the field of grain drying, handling and storage. First- or second-class honours degree essential and research experience desirable, but candidates taking final degree in 1959 will be considered. Salary scale: £615 to £1,090; superannuation under F.S.S.U.—Application forms from Secretary, N.I.A.E., Wrest Park, Silsoe, Beds.

SUB-EDITOR FOR COPY PREPARATION, proof-reading, liaison with authors, editors, printers, etc. Some scientific training and experience of sub-editing an advantage. Good salary, five-day week, etc.—Reply "Personnel," 4 and 5 Fitzroy Square, W.1.

NATURE | *The Leading International Journal of Science*

Published Weekly — Two Shillings and Sixpence

"NATURE" surveys the whole field of pure and applied science, and is authoritative and topical. It is read by scientific workers all over the world.

Every issue includes

A LEADING ARTICLE—on science in relation to modern life and public affairs.
REVIEWS—each by an authority on the subject discussed.
GENERAL ARTICLES—surveying new discoveries and developments.
NEWS and VIEWS—on current topics and events.
DESCRIPTIVE REPORTS—of scientific meetings.
LETTERS TO THE EDITORS and SPECIAL ARTICLES—in which scientific workers of all countries of the world describe their current investigations.

A classified list of recent Scientific and Technical Books is included each month.

The charges for direct postal subscriptions, postage paid to any part of the world, are

12 months	£7 15 0
6 months (26 issues)	£3 17 6
3 months (13 issues)	£1 18 9

Please send me "NATURE" for .... months, beginning with the issue for .....

for which I enclose remittance value .....

Name .....

Address .....

.....

.....

Date.....

MACMILLAN & CO. LTD., St. Martin's Street, London, W.C.2

REED PAPER GROUP

Reed PAPER GROUP

SCIENTIST

A first-class scientist is invited to join the Group Research Department to take charge under the Chief Scientist of a team to be formed to investigate fundamental problems of paper making. Some of these problems are likely to lie in the fields of hydraulics, heat transfer and drying and fibre behaviour.

Although previous experience of the paper industry would be of some value, the most important qualifications are outstanding ability as a scientist and the flair for initiating a programme and leading a research team, which will be engaged both in studying phenomena which occur often at high speed on large and expensive plant and in novel approaches to paper-making.

The appointment is a senior one and will carry a corresponding salary. Conditions of service are excellent.

Applications in writing giving full details of age and experience, should be addressed to

The Group Personnel Officer, The Reed Paper Group,
Larkfield, Nr. Maidstone, Kent.

quoting Ref. S/19.

RESEARCH INVESTIGATOR

required by

ALUMINIUM LABORATORIES LIMITED

for work in a small group on the melting of aluminium alloys, treatment of the molten metal and casting, in ideally situated research laboratories just outside Banbury.

Applicants should be aged 25 to 35 and have a good degree preferably in metallurgy. Experience in melting and casting or post-graduate study of the subject would be an advantage. An interest in thermal transfer or physics of the molten state would be useful.

Pension and Life Assurance scheme in operation.

Apply to Personnel Officer, Southam Road, Banbury.

SHELL CHEMICAL COMPANY LIMITED

has a vacancy in its Technical Service Laboratory in Egham (Surrey) for a

TECHNICAL SERVICE CHEMIST

Applicants should have some experience of paints and other surface coatings and, if possible, a general knowledge of the industrial uses of solvents. Applicants should also hold a recognized qualification in chemistry. Experience in selling or customer approach would be an advantage. Age not more than 32 (male). This is a good post with good prospects for advancement and the salary will be according to age, qualifications and experience.

Generous pension scheme and other benefits.

Write with full details to :
SHELL CHEMICAL COMPANY LIMITED,
PERSONNEL DEPARTMENT,
170 PICCADILLY,
LONDON, W.1.

ORGANIC CHEMISTRY

The British Rayon Research Association has a vacancy for an Assistant in its Organic Chemistry Laboratory. The work will be varied, and will be mainly concerned with the chemical modification of cellulose. Candidates should have G.C.E. (preferably at Advanced level) in physics, mathematics and chemistry. Facilities will be given for further education.

Apply to the Secretary, British Rayon Research Association, Heald Green Laboratories, Wythenshawe, Manchester 22, quoting ref. C.6.

ORGANIC CHEMISTS (TWO) REQUIRED by Pyrethrum Board of Kenya on permanent establishment for investigations on pyrethrins, cinerins, sesamin and other natural products in the laboratories at Nakuru, Kenya. One post would be suitable for a man with Ph.D. or equivalent with several years' experience of synthetic organic chemistry; the other for a freshly-graduated person interested in organic chemistry. Three, four or five year contract initially; 18 days' annual local leave and overseas leave on termination of contract; two months' overseas study leave in U.K. after each 2½ years' service on five-year contract. Nakuru is in the Kenya Highlands at an altitude of 6,500 ft. and the climate is pleasant and temperate. Return air fare paid up to three adult passages. Salary scales: Grade 2 (T), £1,200 to £1,550; Grade 1 (T), £1,600 to £1,950. Initial point of entry according to qualifications and experience. Hard-furnished house or flat available at a rental of not more than 15 per cent of salary with a maximum of £150 per annum. Superannuation or Provident Fund contribution 5 per cent of salary plus 10 per cent contribution by the Board.—Send full details to African Pyrethrum Technical Information Centre Ltd., 4 Grafton Street, London, W.1.

PHYSICAL CHEMIST REQUIRED AT Chesterford Park Research Station, near Saffron Walden (Essex), to work with a team engaged on the synthesis of physiologically active substances for agricultural crop protection. The work will concern the study of reaction kinetics, physico-chemical properties of candidate pesticides, and fundamental aspects of formulation. Applicants should have a degree in chemistry with physics and mathematics as subsidiary subjects. Salary according to age and qualifications.—Full particulars (Quoting No. 1475), to Personnel Manager, Fisons Pest Control Limited, Harston, Cambs.

TECHNICAL LIBRARIAN REQUIRED BY leading Laboratory manufacturers for their Technical Library Information Bureau. The work includes the abstracting and recording of scientific information and the production of an information bulletin. Knowledge of chemistry physics, French and German necessary. Some acquaintance with biology useful. Preferred age range 25-35 years. Excellent prospects. Five-day week. Pension scheme.—Please apply in writing to Personnel Officer, Griffin and George Ltd., Ealing Road, Alperton.

SHELL CHEMICAL COMPANY LIMITED

has vacancies in its London Office for

TECHNICAL/COMMERCIAL ASSISTANTS

Applicants should be male, aged not more than 32 and have experience in the formulation of surface coatings (particularly lacquers) and a good knowledge of solvent and technical processes in the chemical industry. Experience in selling or customer approach would also be desirable. Applicants should also hold a degree or other recognized qualification in chemistry.

Salaries according to age, qualifications and experience. Generous pension scheme and other benefits.

Write with full details to :
SHELL CHEMICAL COMPANY LIMITED,
PERSONNEL DEPARTMENT,
170 PICCADILLY,
LONDON, W.1.

CHIEF DEVELOPMENT ENGINEER

A leading British firm of mechanical engineers is about to appoint a Chief Development Engineer to head a new department in the design and development of new products. Only a man of first-class qualifications and experience will be of interest and the salary will be commensurate with these requirements. The activities of the firm are such as to give full scope to a man with the following alternative minimum qualifications (which are not stated in order of preference).

1. First-class honours degree in Mechanical Science with subsequent design responsibilities in turbines, pumps, boilers, heat exchange equipment, etc.
2. First-class honours degree in Chemical Engineering with subsequent design responsibilities for equipment of the type listed in (1) or for process plant, oil refinery plant, etc.
3. First-class honours degree in Physics with subsequent engineering experience in design of hydrodynamic and thermodynamic systems.
4. First-class honours degree in Mechanical Engineering with subsequent design responsibilities as in (1), (2) or (3).
5. Proven successful senior design responsibility for any equipment as in (1), (2) or (3) and advanced knowledge which may have been obtained without a degree.

The firm recognizes that some of its present staff may be attracted by this advertisement and an application by a member of such staff will be considered along with others without prejudice to his present position.

Continental applicants will require to have adequate English.

Apply Box No. 782, T. G. Scott and Son, Ltd., 1 Clement's Inn, London, W.C.2.

LEVINGTON RESEARCH STATION

LEVINGTON, IPSWICH, SUFFOLK

HORTICULTURAL RESEARCH OFFICER

FISONS Limited invite applications for an interesting and responsible position in the Department of Soil Science at Levington Research Station. The Officer appointed will be engaged in experimental work and administrative duties. Applicants should be graduates (preferably post-doctorate) with experimental experience in horticulture, and a practical background would be advantageous.

The salary offered will depend on qualifications and experience and could be considerable. There is a contributory pension scheme which for married staff covers widows and dependent children.

Applications, giving qualifications, experience and the names of referees, should be sent to the Group Personnel Officer (IG10), Fisons Limited, Harvest House, Felixstowe, Suffolk.

ENGLISH ELECTRIC — ATOMIC POWER DIVISION

REACTOR ENGINEERING DEPARTMENT, Whetstone, near Leicester

PERFORMANCE AND CONTROL OF NUCLEAR POWER STATIONS

Several vacancies, both junior and senior, arise in the department engaged in this work. In particular we need:

ENGINEERS OR PHYSICISTS to undertake performance calculations with special reference to reactor optimisation, economics, and cost forecasting. Also to investigate improvements in the computational techniques of nuclear power station optimisation.

PHYSICISTS OR MATHEMATICIANS to take part in theoretical work on various aspects of nuclear design and reactor physics. The work will involve the solution of many novel and interesting problems.

ENGINEERS for work on reactor and power station control problems. This will include the formulation and functional specification of control systems for reactors and complete power stations. Much of this control will be automatic, and investigation of loop stability, transient responses, operational sequences, and plant safety under fault conditions will be required.

Digital and analogue computing facilities are available for aiding the solution of nuclear performance and control problems.

Senior candidates will probably be 27-32 years of age, with a good degree. They will generally be placed in charge of a small group devoted to some vital aspect of design. In the case of control engineers, familiarity with basic control theory and some appreciation of heat flow problems would be especially valuable.

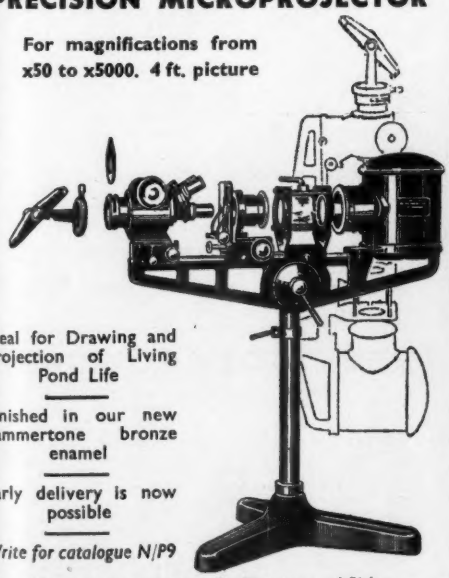
Junior candidates should have sound basic academic qualifications in their subject, though in the case of engineers a degree is not essential if suitable industrial experience exists.

Previous experience in this field, though a considerable asset, particularly for senior applicants, is not essential, as training can be given. Initiative, ability to become "self-propelled," and a keen desire to learn about the whole project are characteristics which will be considered as important as technical qualifications.

If you feel you are suitably qualified and would like to become a member of the team that designed and are now building the world's largest Nuclear Power Station at Hinkley Point, then write, giving details of qualifications and experience, to Dept. C.P.S., Marconi House, 336/7 Strand, W.C.2, quoting reference N1895D.

THE No. 1 PRECISION MICROPROJECTOR

For magnifications from x50 to x5000. 4 ft. picture



Ideal for Drawing and projection of Living Pond Life

Finished in our new hammertone bronze enamel

Early delivery is now possible

Write for catalogue N/P9

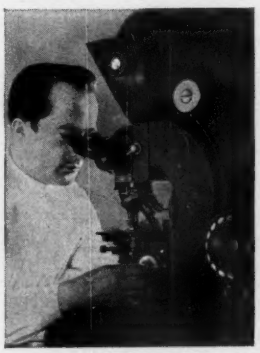
We supply all requirements for Microscopy and Biology

FLATTERS & GARNETT LTD.
309 Oxford Road, Manchester 13
Over 57 Years' Service to Microscopy

ZEISS

ULTRAPHOT II

FULLY AUTOMATIC PHOTO-MICROGRAPHY



Push-button opens camera shutter and exposure time is then automatically adjusted to suit illumination. Fitted screen for micro-projection. Bright field, dark ground, phase contrast and epi illumination.

NOW AVAILABLE FOR DEMONSTRATION

Illustrated booklet on request from the Zeiss agents.

DEGENHARDT & CO., LTD.

6 CAVENDISH SQUARE, LONDON, W.1.

Telephone: LANgham 6097/8/9

Ask also for booklets on

Fluorescence microscopy · Industrial measuring microscopes
Zeiss technoscopes · Colora thermostats · Etc., etc.

ELECTRONICS ENGINEER

required by

ALUMINIUM LABORATORIES LIMITED

at their ideally situated research laboratories just outside Banbury.

Applicants should be of graduate or equivalent status with experience of electronic design and a good working knowledge of mechanical and physical principles. The successful candidate will be required to design, develop and build equipment for the testing and inspection of aluminium products and should have practical ability and a willingness to work on his own initiative.

Pension and Life Assurance scheme in operation.

Apply to Personnel Officer, Southam Road, Banbury.

TECHNICAL RESEARCH AND DEVELOPMENT

Leading British Manufacturer in important industry requires a man of good general education with an honours degree or diploma in chemistry or chemical engineering, and experience in the technology of synthetic resin compositions. Age 30 to 36. Administrative ability, an inventive mind, originality of ideas, and an intense enthusiasm to be first in the field with new products are essential.

This is a responsible position with excellent prospects and only men with a first-class record should apply to The Research Manager, Universal Grinding Wheel Co., Ltd., Stafford.

TRADE ANNOUNCEMENTS

SILICA CONES AND SOCKETS. POLISHED Silica Discs. Ex-stock.—Send for details to Jencons (Scientific) Ltd., Mark Road, Hemel Hempstead, Herts.

GRANTS & SCHOLARSHIPS

McGILL UNIVERSITY
MONTREAL
DEPARTMENT OF ZOOLOGY
GRADUATE ASSISTANTSHIPS AND SCHOLARSHIPS, 1959-60

The Department offers several Teaching Assistantships of a value of at least $1,200 to students proceeding to the M.Sc. or Ph.D. degree. The University offers Carnegie Scholarships for Arctic and Sub-Arctic Research, valued at $2,750, of which $1,250 are set aside towards the expenses of summer field work. These are tenable in the Zoology Department, among others. Also, Canadian Graduate Students are eligible for Scholarships and Grants-in-Aid from the National Research Council and the Fisheries Research Board. Fees ($500) are not waived for holders of scholarships, assistants, etc. The Department is engaged in Research on Growth, Insect Population Dynamics, Histology, Problems on Arctic Zoology and Marine Biology both Arctic and Tropical.

Applications for admission should be made to the Dean, Faculty of Graduate Studies and Research.

ANIMAL HEALTH TRUST
RESEARCH TRAINING SCHOLARSHIPS, 1959

Two or three Research Training Scholarships, including the A. D. Allen Memorial Scholarship, will be offered by the Animal Health Trust. These Scholarships, to the value of £400 to £500 per annum (exempt from income tax) depending upon the location and on the marital status of the successful candidate are available to recently qualified veterinary surgeons and final year students (subject to July examination results) who are desirous of undertaking further specialist study or supervised research to fit them better for an academic, research or specialist career. In addition, a sum not exceeding £60 per annum may be given towards the payment of essential fees. The awards will be made in June.

Forms of application can be obtained from The Scientific Director, the Animal Health Trust, 14 Ashley Place, Westminster, London, S.W.1. Closing date for receipt of applications is Monday, April 27, 1959.

IMPERIAL COLLEGE: BURSARY OF £425, out of which fees must be paid, provided by a group of Optical Instrument Firms, available for one year for the postgraduate course in Technical Optics.—Further particulars from the Registrar, Imperial College, London, S.W.7. Closing date, June 1, 1959.

TOBACCO RESEARCH BOARD OF RHODESIA AND NYASALAND
POSTGRADUATE BURSARY

A Bursary of £600, tenable for one year at the Imperial College of Science and Technology, London, is offered to a B.Sc. honours graduate who has majored in zoology or botany, with the other subject as a subsidiary, to undertake a post-graduate course in Nematology, leading to the diploma D.I.C. This course will commence in September, 1959. The selected candidate will be required to give an undertaking that, on completion of the course, he will serve on the Board's salaried staff for a minimum period of three years.

Applications must be submitted on the appropriate form, which may be obtained on request from the Secretary, P.O. Box 1909, Salisbury, Southern Rhodesia. The closing date for the receipt of applications will be April 30, 1959.

UNIVERSITY OF OXFORD
METALLURGICAL RESEARCH

Two Research Bursaries are offered for work in the Department of Metallurgy on the constitution and mechanical properties of alloys at very high temperatures. The Bursars are expected to read for the Oxford D.Phil. degree, and the work provides valuable research experience for those interested in materials for use at high temperatures. The bursaries are of value equivalent to those of D.S.I.R. Research Studentships (at present £420 per annum tax free, plus approved fees). Candidates should have a first- or second-class honours degree in metallurgy, physics or chemistry, and should apply before May 15 to Professor W. Hume-Rothery, O.B.E., F.R.S., Department of Metallurgy, University Museum, Parks Road, Oxford. Applications can be considered from those graduating in the summer of 1959.

FOR SALE AND WANTED

SCRAP PLATINUM URGENTLY WANTED—13s. per gram for scrap platinum apparatus, wire, etc.—Send registered to the Scientific Metal Co., Dept. N., 50 Old Brompton Road, S.W.7. Cash or cheque by return. Also urgently required—waste mercury and silver residues, etc.

ALMOST ANY BACKNUMBERS AND volumes of *Nature* wanted. Also learned and scientific journals, transactions of most kinds. Further: *Notes and Queries*, the *Annual Register*, *Quarterly Review*, *Palmer's* and/or the *Official Index* to the *Times*, *British National Bibliography*, *English Catalogue of Books*, *Journal Royal Philosophical Society*, *Royal Statistical Society*, etc.—H. Pordes, 138 New Cavendish Street, London, W.1. MUSeum 5250.

SILICONE RUBBER

TUBING, BUNGS, STRIP, WASHERS, BOTTLE CAP LINERS & MOULDINGS MADE TO SPECIFICATION

ESCO (RUBBER) LTD

2 Stothard Place, Bishopsgate, London, E.C.2

All communications regarding advertising in NATURE should be addressed to:

T. G. SCOTT & SON LTD.,
1 Clement's Inn, London, W.C.2

DOES THE WORK OF OVENS TWICE ITS PRICE

More than 300 already made and sold! And they're doing a grand job at a big money-saving cost! Standard model (£26) capacity 12" × 12" × 14". Fitted 3 steel weld-mesh trays. Temp. range 50° C.—250° C. controlled by easy-read thermostat calibrated in degrees C. Power consumption 600 watts.

Pickstone

ONLY £26

THERMOSTATIC OVEN

Order with confidence or request full details

R. E. PICKSTONE LTD

56/60 Islington Park Street, London N.1 Tel: CAN 6190

LABORATORY EQUIPMENT

VACUUM PUMPS, brand new, 7 cu. ft. per min. 10 lbs. per sq. in. at 1,200 r.p.m. Rotary vane type, 35/-. Post 3/-.

VARIABLE TRANSFORMER, 230 volts A.C., 50/60 cycles. Output infinitely variable from 0-270 volts 9 amps, brand new, £15, cge. 12/6.

SYNCHRONOUS MOTOR, 200/250 volt A.C., 60 r.p.m., suitable for electric clocks, etc., 25/-, post 2/6.

SYNCHRONOUS MOTOR, 200/250 volts A.C., 50 cycles, with gear train driving 5 dials from 1/10th hr. to 10,000 hrs., 35/-, post 2/6.

RACKS—POST OFFICE STANDARD, 6 ft. high with U-channel side drilled for 19 in. panels heavy angle base. 4 ft. 10 in. also in stock. Send s.a.e. for latest lists.

L. WILKINSON (CROYDON) LTD.
19 LANSDOWNE RD. CROYDON SURREY